C. J. Taylor
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INSTRUCTION BOOK

WRIGHT CYCLONE 9 AIRCRAFT ENGINE

SERIES

C9-GC

Installation, Operation, and Service Maintenance

Second Edition

WRIGHT AERONAUTICAL CORPORATION
(A Division of Curtiss-Wright Corporation)
PATERSON, NEW JERSEY
September, 1942

WRIGHT GUARANTEE

WE WARRANT each new engine manufactured by us to be free from defects in material and workmanship under normal use and service and proper installation; our obligation under this warranty being limited to making good at our factory any part or parts thereof, which shall, within ninety (90) days after delivery of such engine to the original purchaser, be returned to us with transportation charges prepaid, and which our examination shall disclose to our satisfaction to have been defective; this warranty being expressly in lieu of all warranties, expressed or implied, and of all other obligations or liabilities on our part; and we neither assume nor authorize any other person to assume for us any other liability in connection with the sale of our engines.

This warranty does not cover any labor charges for the replacement of parts, adjustments, repairs, or any other work done on Wright engines.

This warranty shall not apply to any engine which shall have been repaired or altered outside of our factory in any way, so as, in our judgment, to affect its performance or reliability, or which has been subject to misuse, negligence, or accident, or which shall have been operated at powers or speeds in excess of the engine specification limitations.

This warranty shall not apply to any engine which shall have been operated with other than specified fuel and oil.

We reserve the right to revise, change, or modify the whole or any part of the construction of Wright engines, without incurring any obligation to make the changes on engines previously sold.

We make no warranty whatever in respect to ignition, starting devices, generators, carburetors, or other trade accessories, inasmuch as these are usually warranted separately by their respective manufacturers.

PREFACE

THIS MANUAL, which is a revised edition, and supersedes all previous editions of this publication, has been written with the intention of supplying the necessary instructions for the installation, operation, and service maintenance of Wright Cyclone 9-GC (formerly designated as GR-1820-G200) Aircraft Engines. A thorough knowledge of the correct installation, operation, and maintenance routine enables the operator to get the best service from his engine. Under the heading "Troubles," tables of the more elementary troubles and their causes are submitted with the object of reducing wasted time and increasing the reliability of the engine. This section should be read by the experienced as well as the new operator. The life of the engine depends upon proper care as well as upon its proper operation. For the pilot are included instructions for handling the engine, and for the hangar personnel, hints on its daily care.

Many points may seem to the reader to be of small importance and unduly stressed. These points have been emphasized, however, because experience has indicated that they should receive special attention.

Wright Aeronautical Corporation Service Bulletins, issued subsequent to the date of publication of this book, are applicable to, and may supersede, instructions contained herein.

The installation drawings included in this edition are basic drawings for the Cyclone 9-GC series engines. Supplementary drawings covering accessories for several types of installation are issued from time to time. These supplementary drawings may be obtained upon request from the Wright Aeronautical Corporation.

The Wright Aeronautical Corporation welcomes suggestions for improving the engine, its equipment, or its servicing and invites constructive criticism of this manual. Such suggestions are greatly appreciated and will receive careful consideration.

TABLE OF CONTENTS

Wright Guarantee III
Preface V
List of Illustrations IX
Released Materials and Accessories.......... XI
Three-Quarter Right Rear View XII
Three-Quarter Left Rear View XIII
Engine Characteristics .... XIV & XV
Three-Quarter Left Front View XVI

CHAPTER I

Page

General Description 1

Page

Cylinders 1
Air Deflectors 1
Crankcase 2
Accessory Drive Mechanism 5
Crankshaft 7
Propeller Shaft and Reduction Gear 9
Torque Indicator 9
Connecting Rods 10
Knuckle Pins 11
Piston Pins 12
Pistons and Rings 12
Valve Operating Mechanism 12
Valves and Valve Springs 13
Supercharger 14
Single-Speed Supercharger 15
Two-Speed Supercharger Drive
(Plate Clutch Type) 15
Two-Speed Supercharger Drive
(Roller Clutch Type) 16
Lubrication 19
Carburetion 22
Ignition 24
Generator Drive 25
Tachometer Drives 25
Dual Accessory Drive 25
Fuel Pump Drive 27

CHAPTER II

Preparation for Storage or Service 29

General 29
Unleaded Fuel Runout 29
Equipment 29
Slushing Procedure 30
Packing Procedure 32
Distribution of Dehydrating Agent 33
Sealing the Envelope 33
Inspection 34
Maintenance 34
Unpacking 34

CHAPTER III

Installation in the Airplane 35

Unpacking and Preparation for Service 35
Method of Mounting Engine 36
Intake Pipes 36
Accessory Drives 37
Magneto Oil Drain 37
Fuel System 37
Lubrication System 37
Propeller Governor 37
Propellers 38
Inspection of Engine Installation 38
Exhaust Gas Analyzer 38
Manifold Pressure Gauge Line 38
Fuel and Oil Lines 38

CHAPTER IV

Starting and Normal Operation 41

Pre-Oiling 41
Filling 41
Cold Weather Precautions 42
Oil Dilution 42
Pre-Flight Inspection 42
Starting Instructions 43
Warm-Up 44
Performance Check 44
Take Off and Climb 45
Rated Power Climb 45
Cruising Power Climb 45
Level Flight, Rated Power 46
Level Flight, Cruising Power 46
Descent to about 500 ft. above Airport 46
At 500 ft. above Airport 46
Stopping the Engine 46
Feathering 47
Unfeathering 47
General 48
Flight 48
Mixture Control 48
Carburetor Air Scoop Operation 49
Fuel Supply Valves 49
Runout on Unleaded Fuel 49
Fuel Specifications 49

CHAPTER V

Page

Wright Engine Performance Curves 51

Page

Description 51

Method of Reading Engine Performance Curves 51

CHAPTER VI

Engine Troubles 53

Failure of Engine to Start 53

Low Oil Pressure 53

Oil Accumulation in Crankcase 54

Excessive Oil Temperature, High Oil Consumption 54

Low Power and Uneven Running 54

Loss of Power, Stormy Weather 55

Spark Plugs 55

Magnetos 55

Carburetor Leakage 55

CHAPTER VII

Periodic Inspection Routine 57

General 57

Starting Inspection 57

Daily Inspection 57

Fifty Hour Inspection 58

1. Compression 58
2. Valve Gear 58
3. Ignition 58
4. Lubrication System 58
5. Fuel and Induction System 59
6. Exhaust System 59
7. External Nuts 59

Miscellaneous 59

CHAPTER VIII

Service Maintenance 61

General 61

Overhaul Stand 61

Tools 61

Cleaning Engine Parts 61

Spark Plugs 62

Cylinder Air Deflectors 62

Priming System 62

Intake Pipes 63

Sealing Compound 63

Spark Plug Wells 63

Spark Plug Elbows 63

Magneto Block Terminal Wells 63

Ignition Harness 64

Magneto Distributor Block 65

Magnetos 66

Carburetor Air Scoop, Carburetor, and Adapter 68

Oil Pump and Tachometer 68

Oil Pressure Relief Valve 68

Oil Pump Check Valve 69

Cuno Automatic Filter 69

Supercharger Drain Valve 69

Supercharger Oil Seal Vent 70

Dual Accessory Drive Assembly 70

Oil Sump 71

Push Rods and Valve Tappets 71

Cylinders and Pistons 73

Crankpin Oil Metering Jet 73

Checking Valve Timing 77

Propeller Shaft Thrust Bearing Nut 78

External Oil Scavenge Line 79

Generator 79

Starter 80

Propeller Governor 80

Breather Tube 80

Crankcase Front Section 80

Fuel Pump Drive Shaft and Oil Seal Replacement 81

Generator and Magneto Drive Shaft Oil Seals 81

Starter Oil Seal Ring 81

Hydromatic Propeller 81

Material Specifications

Corrosion Preventive—Compound 82

Corrosion Preventive—Oil 84

Lubricating Oil 85

Fuel 86

Table of Limits — Tightening Torque Values

Lubrication Charts

Installation Drawing

LIST OF ILLUSTRATIONS

TITLE	Page
Cyclone 9-GC—Three-Quarter Right Rear View	XII
Cyclone 9-GC—Three-Quarter Left Rear View	XIII
Cyclone 9-GC—Three-Quarter Left Front View	XVI

TITLE	Page
Accessory Drives, Relative Position of, Showing Direction of Rotation	27
Cam and Cam Drive	12
Cam Driving Gear Teeth, Correct Meshing of.	77
Crankcase, Front Section	2
Crankcase, Main Section	3
Crankshaft	7
Cylinder, Intake Pipe, Piston and Piston Rings	11
Cylinder, Tightening Hold-down Cap Screw Using Torque Wrench	75
Cuno Oil Filter	69
Distributor Block, Attaching Wire in	65
Dual Accessory Drive Mechanism	26
Generator Drive	25
Gun Synchronizer Impulse Generator	6
Hoisting Sling, Arrangement of	36
Ignition Harness	24
Ignition Wiring Diagram	79
Impeller and Impeller Shaft	14
Installing	
Cylinder	74
Piston Pin Retainer	74
Intake Pipe Packing Nut, Loosening	36
Magneto Drive Showing Gun Synchronizer Cover Plate	6
Master Rod Showing End Seal Disc, Articulated Rod, Lock Plate, and Spacer	10
Oil Pump Assembly	22
Oil Pump Assembly with Provision for External Oil Scavenge Line	23
Oil Pump and Fuel Pump Drives	26
Overhaul Stand, Mounting Engine on	61
Reduction Gear, 3:2	8
Reduction Gear, 16:9	9
Removing	
Engine from Shipping Box Showing Hoist Arrangement	35
Crankcase Front Section	80
Cylinder	73
Mounting Plate	35
Piston Pin Retainer	74
Slushing the Combustion Chamber	31
Slushing Plugs—Bendix-Stromberg Carburetor	33
Supercharger Drive	
Single-Speed	15
Two-Speed, Plate Clutch	16
Two-Speed, Roller Clutch	17
Supercharger Impeller and Shaft	5
Supercharger Front and Rear Housings and Diffuser Plate	3
Supercharger Rear Housing Cover	4
Timing the Magneto	67
Timing Marks on Reduction Driving Gear	78
Typical Wright Cyclone 9-GC Engine Performance Chart	50
Valve Mechanism	13
Valve Tappet Clearance, Setting	76

RELEASED MATERIALS AND ACCESSORIES

THE WRIGHT AERONAUTICAL CORPORATION conducts a continual investigation of a large number of materials and accessories to determine which may be used with each model of Wright aircraft engines, without impairing or adversely affecting the proper functioning or reliability of the engine. Certain materials and accessories thus investigated have been released by the Wright Aeronautical Corporation for use with each model of Wright aircraft engines. Such a release signifies that the specified material or accessory may be used with the specified engine model, without thereby voiding the engine guarantee. The use of materials and accessories, not released by the Wright Aeronautical Corporation, constitutes a misuse of the engine and voids the guarantee.

The release of a material or accessory by the Wright Aeronautical Corporation is not a guarantee by the engine manufacturer of the durability or satisfactory operation of such material or accessory, inasmuch as it is usually guaranteed separately by its manufacturer.

Two classifications of released materials and accessories exist:

1. Materials and accessories supplied but not manufactured by the Wright Aeronautical Corporation, such as carburetors, magnetos, oil strainers, ignition wire, and ignition wiring harnesses. Materials and accessories in this classification are released only when procured from the Wright Aeronautical Corporation or through its authorized agents. Replacement parts for released accessories in this classification must be procured from the accessory manufacturer, or through the authorized agents of that manufacturer, or from the Wright Aeronautical Corporation, or through its authorized agents. Adequate service instructions for these accessories will be furnished by the accessory manufacturer upon request.

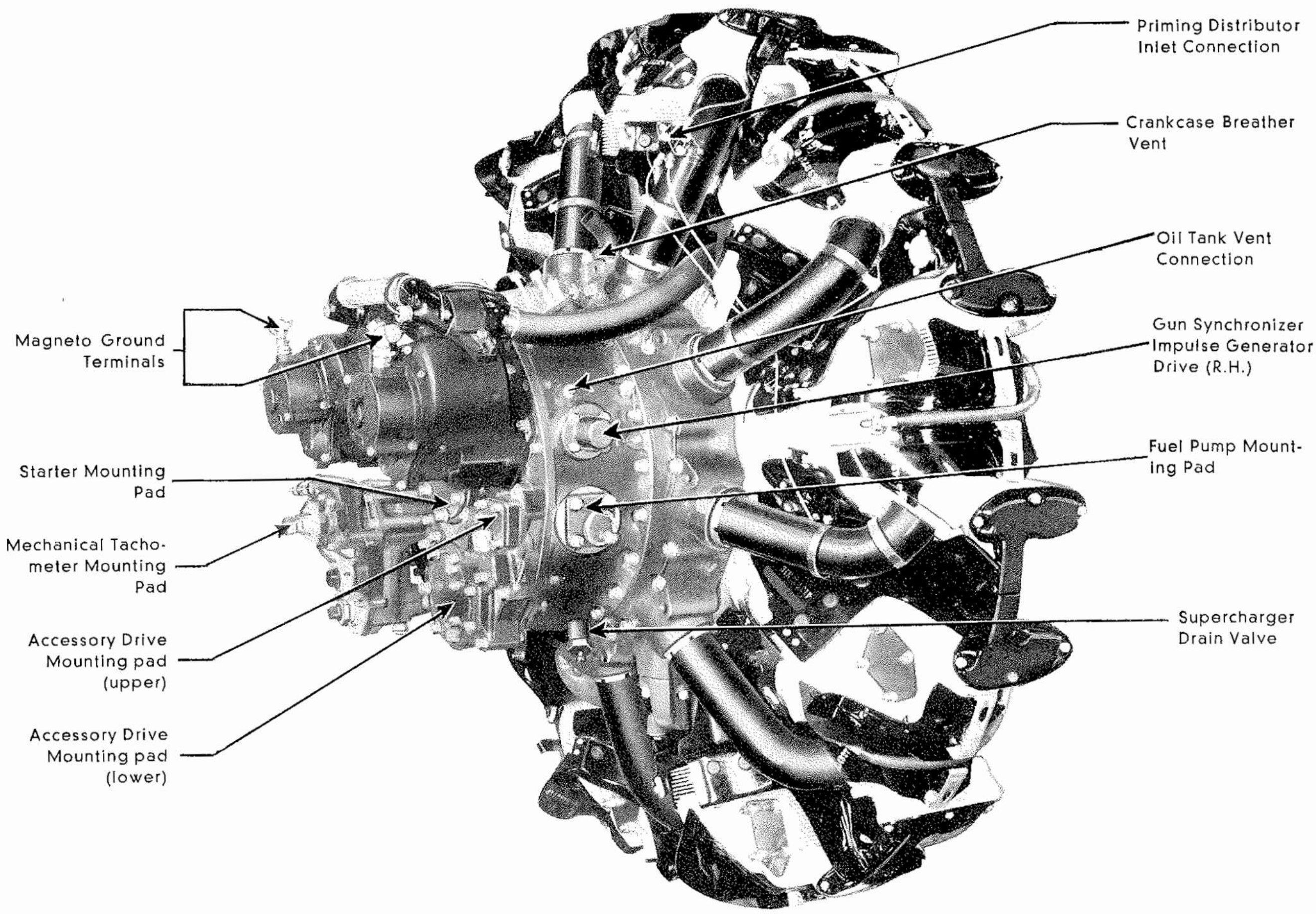
2. Materials and accessories neither manufactured nor normally supplied by the Wright Aeronautical Corporation, such as fuels, lubricating oils, spark plugs, fuel pumps, starters, generators, alternators, vacuum pumps and hydraulic pumps. Spark plugs, although supplied by the engine manufacturer with new engines, are handled as an accommodation only. Whenever possible, spark plugs should be purchased directly from the spark plug manufacturer or through that manufacturer's authorized representative. Replacement parts for released accessories in this classification must be procured from the accessory manufacturer or through the authorized agents of that manufacturer.

All released materials and accessories in group 1 are listed in the parts catalogs, parts lists, or other publications of the Wright Aeronautical Corporation.

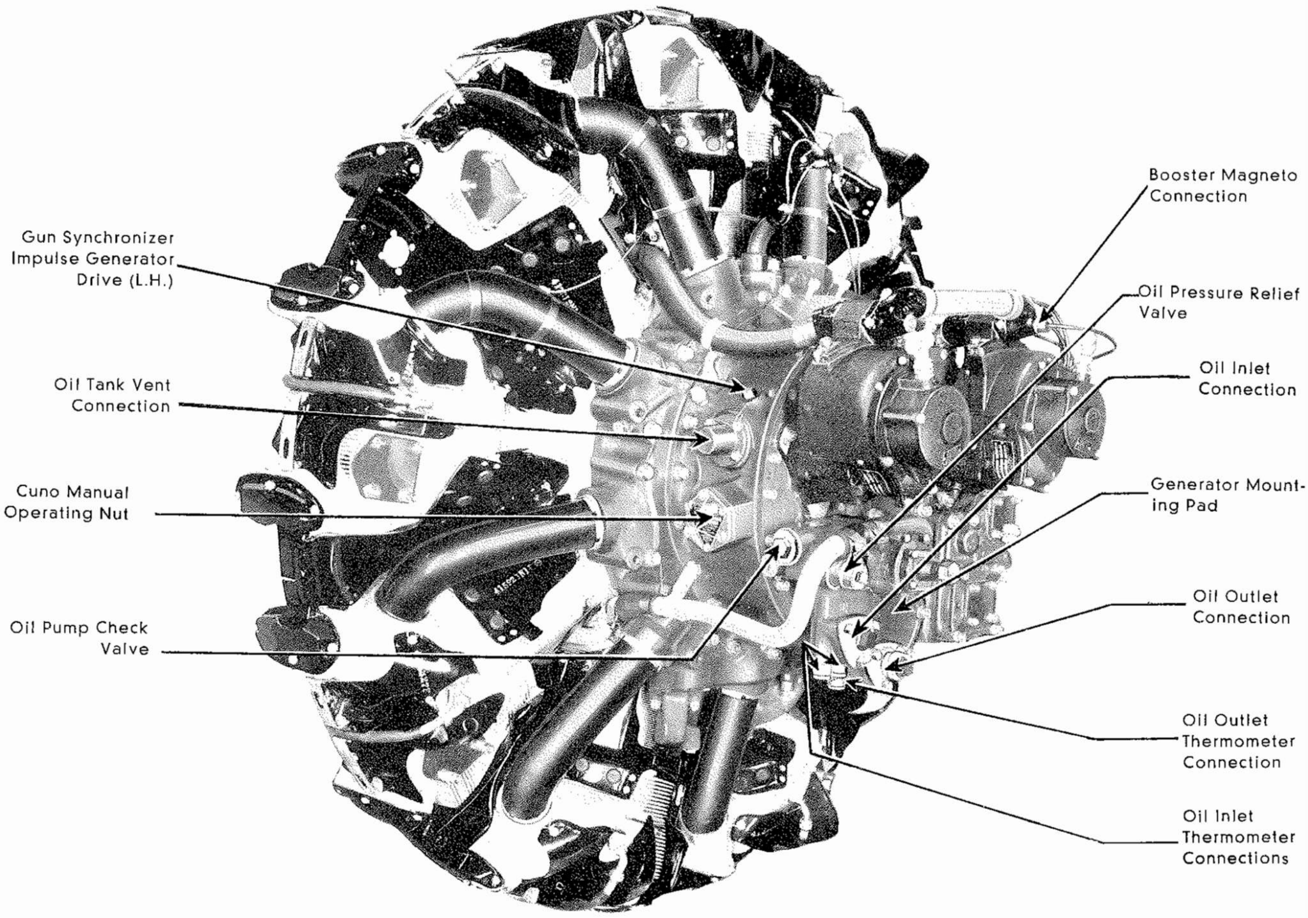
A wide selection of released materials and accessories in group 2 is available for each engine model and installation. A complete list of these items is not published by the Wright Aeronautical Corporation, because it would be practically impossible to keep such a large publication up to date with current releases. However, detailed information on these releases may be obtained upon request from the Service Division. When requesting such information, give the model designation and serial number of the engine involved. For the convenience of service stations and operators, bulletins will occasionally be issued listing certain released materials and accessories, such as engine lubricating oils and spark plugs.

Engine materials and accessories released by the Wright Aeronautical Corporation are recommended in the interest of safe flying, and to assist the operator in obtaining the maximum performance, reliability, and service life from his engines. It is therefore highly recommended that operators communicate with the Service Division: whenever there is any doubt as to a release; prior to any action concerning the installation of accessories on engines in new aircraft; prior to the installation of accessories on modernized engines; prior to the installation of additional accessories on any engine; or prior to any changes which are to be made in the materials or accessories used with any engine.

Under no conditions should any structural engine part, such as an oil pump, bearing, valve, bushing, gasket, or piston ring, which has not been procured from the Wright Aeronautical Corporation, or through its authorized agents, be used on a Wright aircraft engine. The use of such a part is contrary to the interests of safe engine operation and voids the engine guarantee.



WRIGHT CYCLONE 9-GC AIRCRAFT ENGINE
(Three-Quarter Right Rear View)



WRIGHT CYCLONE 9-GC AIRCRAFT ENGINE
(Three-Quarter Left Rear View)

ENGINE CHARACTERISTICS

NAME .... Wright Cyclone

SERIES C9-GC
(Formerly GR-1820-G205A, GR-1820-G205B, GR-1820-G203A, GR-1820-G203B, GR-1820-G202A, GR-1820-G202B)

TYPE .... Single Row—Static Radial—Air Cooled

NUMBER OF CYLINDERS 9

BORE .... 6.125 in.—155.6 mm

STROKE .... 6.875 in.—174.6 mm

DISPLACEMENT .... 1823 cu. in.—29.88 lit

COMPRESSION RATIO .... 6.7:1 or 6.3:1

RATED R.P.M. OF CRANKSHAFT 2300

RECOMMENDED CRUISING R.P.M. OF CRANKSHAFT 1900

MAXIMUM CRUISING R.P.M. OF CRANKSHAFT 2000

REDUCTION GEAR RATIO (Crankshaft to Propeller) .... .666 or .5625

ROTATION OF PROPELLER SHAFT (Looking at anti-prop. end).. Clockwise

GRADE OF OIL REQUIRED .... W.A.C. Spec. No. 5817, Grade 120

OIL CONSUMPTION (Approx. Max.—Service Figs. May Be Lower)
At Rated R.P.M. .... 0.025 lb./hp./hr.—11.39gm/hp./hr.
At 1900 R.P.M. .... 0.020 lb./hp./hr.—9.1 gm/hp./hr.

OIL IN TEMPERATURE IN FLIGHT (Desired) .... 165 deg. F.— 74 deg. C.

OIL IN TEMPERATURE IN FLIGHT (Max.) .... 190 deg. F.— 88 deg. C.
(Emergency only) .... 220 deg. F.—104 deg. C.

OIL PRESSURE IN FLIGHT (At connection to right of oil tank vent on rear cover) .... 65-75 lb./sq. in.—4.58-5.28 kg/sq. cm

HEAT TO OIL AT NORMAL POWER AND RATED R.P.M. (Approx. Max.) .... 2000 B.t.u./min.—504 kg cal./min.

OIL CIRCULATION AT RATED POWER AT 220 DEG. F. OIL IN TEMPERATURE AND 65 lb./sq. in. PRESSURE (APPROX. MAX.).. 80 lb./min.—36.3 kg/min.

FUEL CONSUMPTION
Curves which accompany the "Engine Specification" show minimum fuel consumption values attainable under favorable conditions. Sample curves are included in this Instruction Book.

FUEL REQUIRED

ENGINE	W.A.C. SPEC. NO.	OCTANE RATING
C9-GC	5804	91
	5806	100

The engine specification or engine data plate should be checked to confirm the proper grade of fuel for a particular model engine.

ENGINE CHARACTERISTICS

FUEL SUPPLY PRESSURE

Stromberg Carburetor	13-18 lb./sq. in.—0.91-1.26 kg/sq.cm
Holley CG	6.0-7.0 lb./sq. in.—0.42-0.49 kg/sq.cm
Chandler Evans	6.0-7.0 lb./sq. in.—0.42-0.49 kg/sq.cm

CYLINDER TEMPERATURES	HEAD—SPARK PLUG WASHER COUPLE	BASE EMBEDDED COUPLE
Ground Operation (60% rated speed)	450 deg. F.—232 deg. C.	325 deg. F.—163 deg. C.
Rated Power Climb & Level Flight	425 deg. F.—218 deg. C.	300 deg. F.—149 deg. C.
Cruising Power Climb	425 deg. F.—218 deg. C.	300 deg. F.—149 deg. C.
Cruising Power Level Flight	400 deg. F.—205 deg. C.	300 deg. F.—149 deg. C.
Single Engine Climb & Level Flight	450 deg. F.—232 deg. C.	325 deg. F.—163 deg. C.

PROPELLER SHAFT SPLINE SIZE .... S.A.E. No. 50

LENGTH BARE ENGINE .... 50.04 in.—127 cm

DIAMETER BARE ENGINE .... 55.1 in.—140 cm

DRY WEIGHT OF BARE ENGINE INCLUDES THE FOLLOWING:

- Scintilla Magnetos, Radio Shielded
- Ignition Wiring and Spark Plugs, Radio Shielded
- Carburetor
- Cylinder Barrel and Head Baffles
- Exhaust Stack Flanges and Gaskets
- Generator Drive
- Fuel Pump Drive
- Accessory Drive
- Tachometer Drives (two)
- Automatic Valve Gear Lubrication
- Provision for Hydraulic Controllable Propeller
- Provision for Gun Synchronizer Impulse Generator Drives (two)

TOTAL DRY WEIGHT ± 1%

C9-GC .... 1320 lb.—597 kg

WEIGHT OF EQUIPMENT NOT INCLUDED IN DRY WEIGHT OF BARE ENGINE:

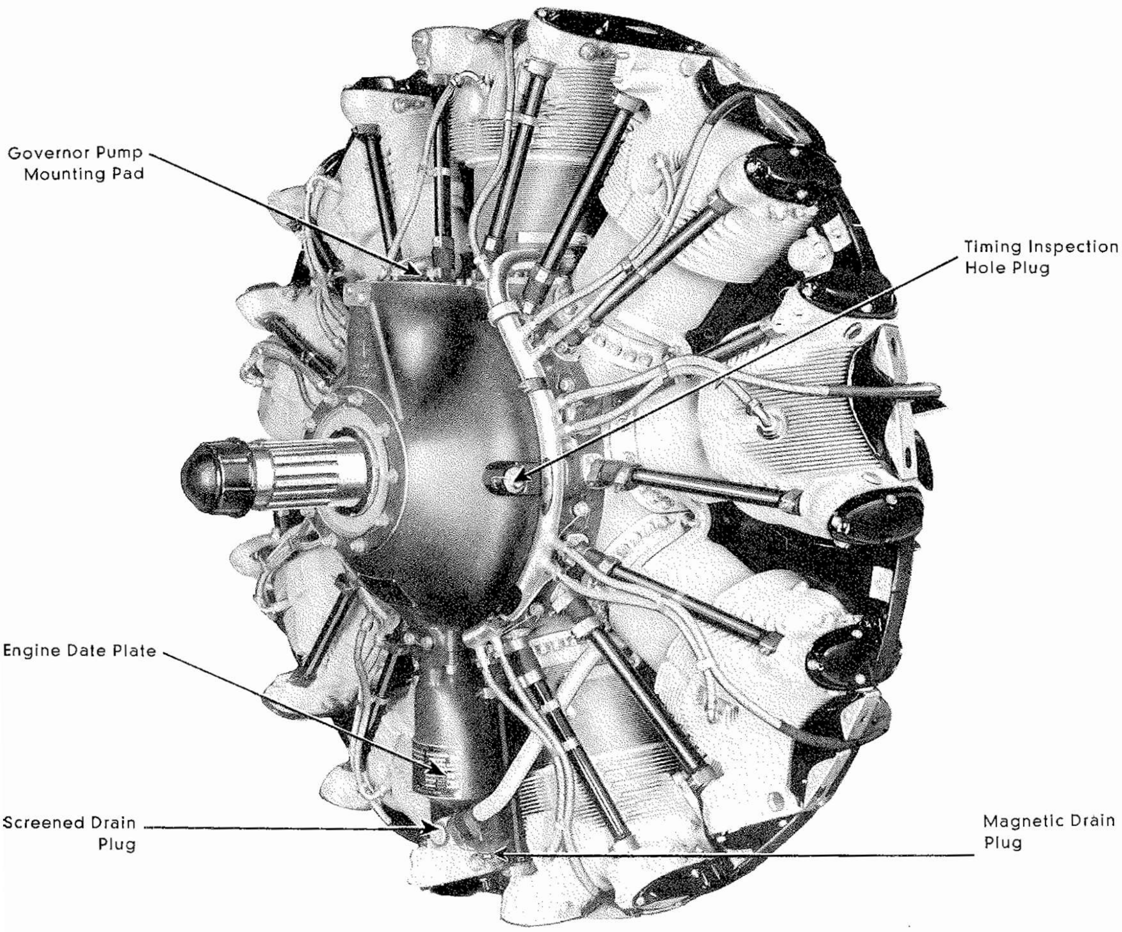
Lifting Cable Assembly	3.25 lb.—1.47 kg
Tool Kit	18.00 lb.—2.16 kg
Instruction Book	1.0 lb.—0.45 kg
(Domestic Shipping Box—70" x 61" x 58" High Approx.)	725.00 lb.—328.00 kg

APPROX. TOTAL DOMESTIC SHIPPING WEIGHT

C9-GC Series Engines: .... 2067 lb.—935 kg

(Delivery F.O.B. Paterson, New Jersey)

Detailed information concerning a particular model of Series C9-GC engines may be obtained upon request from the Wright Aeronautical Corporation, Service Division.



WRIGHT CYCLONE 9-GC AIRCRAFT ENGINE
(Three-Quarter Left Front View)

CHAPTER I

GENERAL DESCRIPTION

THE WRIGHT CYCLONE 9-GC engine (formerly designated as the GR-1820-G200 model) is of the single row, nine cylinder, air cooled, static radial type, operating on the conventional four stroke cycle. The cylinder bore is 6.125 inches (155.6mm), and the piston stroke is 6.875 inches (174.6mm), giving a total piston displacement of 1823 cubic inches (29.88 liters). Cylinders are fired in the following order: 1, 3, 5, 7, 9, 2, 4, 6, 8, clockwise, viewed from the rear of the engine.

Throughout this book the propeller end of the engine will be referred to as the "Front" of the engine, and the anti-propeller end will be referred to as the "Rear" of the engine.

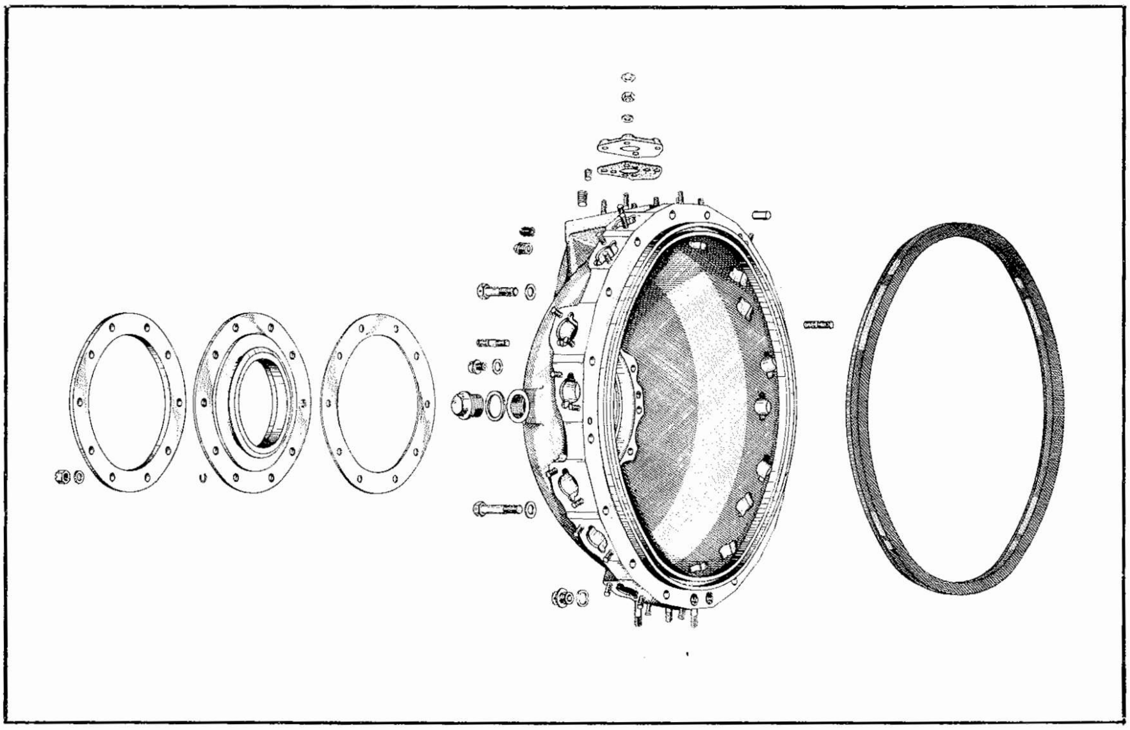
The terms "Right" and "Left" refer to the viewpoint of an observer facing the anti-propeller or rear end of the engine. Rotation of the propeller is clockwise as viewed from this position. The cylinders are numbered in a clockwise direction beginning with the top cylinder as number one. The term "Horizontal Position" will be used to designate the position of the engine in level flight.

CYLINDERS The cylinders are built up by shrinking threaded cast aluminum alloy heads on forged steel barrels. Cooling fins are cast in the cylinder head and machined in the barrel. The exhaust port boss faces toward the rear of the engine and is provided with four studs for securing the exhaust stacks. The intake port boss is at the rear of the cylinder head and faces toward the right and slightly downward, toward the center of the engine, in order to allow for smooth uninterrupted flow of mixture to the cylinder. Rubber packing is used between the intake pipe flange and cylinder head. A boss, located just forward of the intake pipe flange on each cylinder intake port, is drilled and tapped to receive either a priming line fitting or a plug. The valves are inclined to the center line of the cylinder at an angle, permitting a hemispherical combustion chamber. Bronze valve guides and steel valve seats are shrunk into the cylinder head. Bronze spark plug inserts are screwed and pinned in the front and rear of each cylinder head. The inserts are just above the main horizontal cooling fins of the head and located symmetrically and at 90° to each other. They are surrounded with deep vertical cooling fins.

The intake and exhaust rocker boxes are provided with four studs for securing the rocker box covers. The rocker arm bolt bosses are equipped with bronze bushings. Bosses equipped with studs are cast at the front and rear of the intake rocker boxes for securing the engine cowling. Push rod housing connections are screwed into the forward end of the rocker boxes forming oil tight seals. The rocker box covers are provided with integrally cast extensions which form a complete circle around the engine when assembled. Intercylinder baffles are attached to these extensions with plates, making a satisfactory air seal without the use of leather seals.

The cylinder barrel, with integral cooling fins, attaching flange, and threads to secure the head, is machined from a steel forging. The surface of the cylinder bore is nitrided to provide increased life. Twenty holes are provided in the cylinder attaching flange for attachment of the cylinder assembly to the crankcase by cap screws. Spherical seat washers are used under the cap screw heads.

AIR DEFLECTORS Pressure type, close seating, cylinder head and barrel air deflectors of sheet aluminum alloy are used to direct the flow of air through the cooling fins with maximum efficiency. Because of a variance in the construction of the deflectors used in different locations on the engine, care should be taken to mark each deflector removed from the engine to insure correct re-installation.



Crankcase Front Section

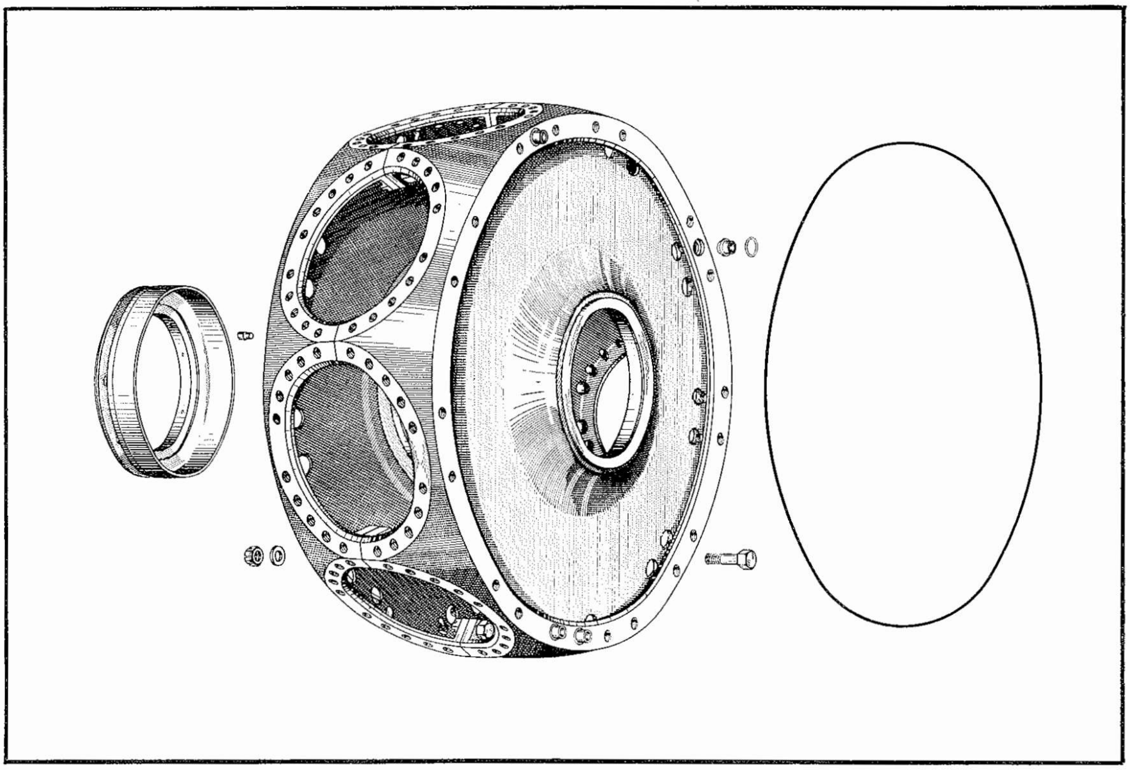
CRANKCASE The crankcase is built up of six principal sections of heat-treated metal alloy. The front section, a magnesium alloy casting, contains the main thrust ball bearing and furnishes support for the cam followers or tappets which actuate the valves through push rods and rocker arms. The stationary reduction gear and reduction gear pinion guard ring are bolted at the forward end inside the front section. The governor drive assembly consists of a single vertical shaft mounted in the front section. The bevel gear drive is taken from the intermediate governor drive gear mounted on the cam intermediate drive gear.

A steel thrust nut oil seal ring flange and aluminum spacer are bolted to the front face of the front section. The thrust nut oil seal rings bear on the inside circumference of this flange. The forward end of the oil sump is attached to the lower part of the front section. The front section contains oil passages for the hydro high and hydro low pressure oil, used in conjunction with a hydraulically operated propeller. The inner rear parting surface of the front section includes a channel, sealed by a rubber packing ring, which carries oil to the tappet assemblies.

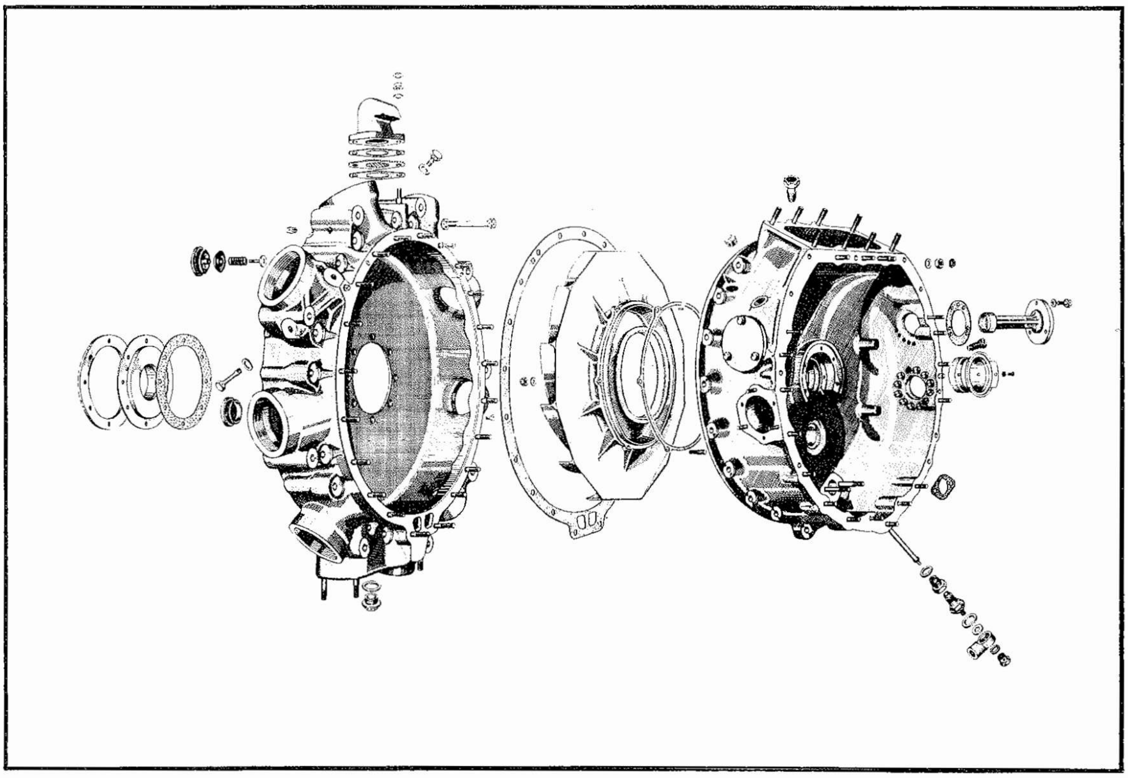
The crankcase front section is attached to the crankcase front main section by cap screws.

The crankcase front and rear main sections are machined from steel forgings. They are parted on the cylinder center line and are attached by short bolts through internal lugs. A boss in the center of the front half is provided to receive the cam. A bronze cam bearing is shrunk on the outside circumference of this boss.

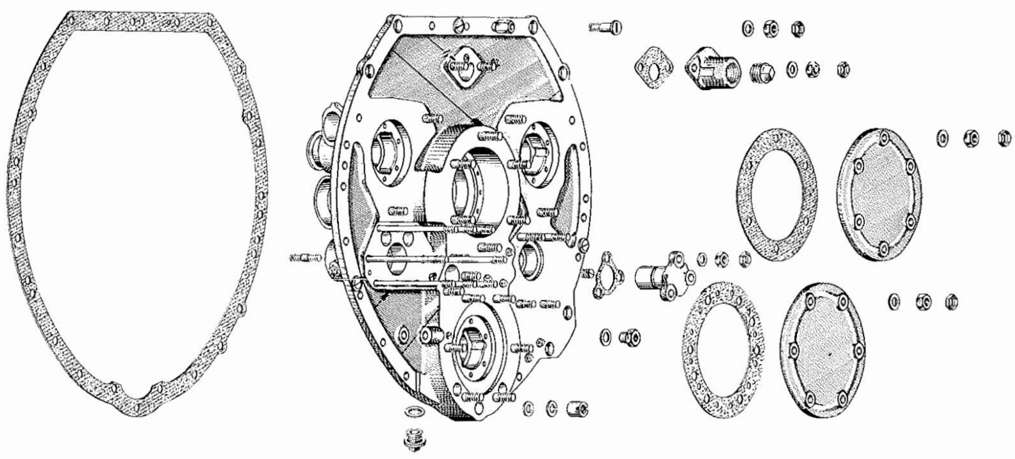
The supercharger front housing is machined from a magnesium alloy casting having nine mounting lugs for supporting the engine and nine tapped bosses for intake pipe connections. The diaphragm or web of the supercharger front housing forms the forward wall of the diffuser section and distribution chamber. The impeller shaft front oil sleeve support is mounted on the diaphragm and held in place by a steel retainer ring which is secured to the diaphragm by eight short screws. The front wall is cored around the rim to form a breather passage. Bosses with tapped holes are provided at the base of the intake pipe connections to cylinders No. 2, 8, and 9 for priming line and manifold pressure connections. Five plugs are permanently installed in the front wall of the supercharger front section for manufacturing purposes and a crankcase breather relief valve is screwed into the remaining hole. Cored holes in the bottom of the housing form drainage and suction passages to the oil sump which is attached to the bottom



Crankcase Main Section



Supercharger Front and Rear Housings and Diffuser Plate

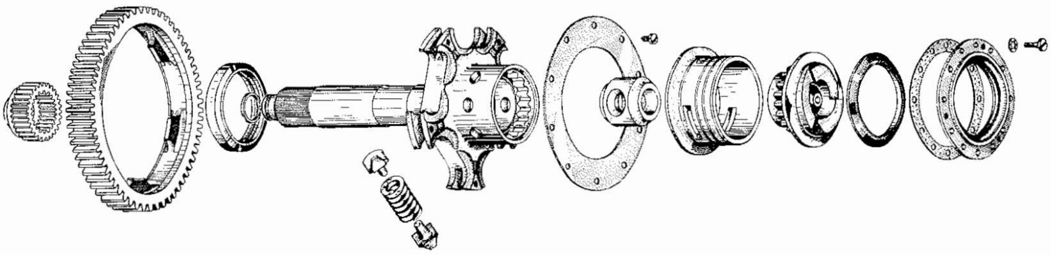


Supercharger Rear Housing Cover

of the crankcase front section and the supercharger front housing. The supercharger front housing is attached to the crankcase rear main section by means of eighteen cap screws.

The magnesium alloy supercharger rear housing contains the induction passage to the impeller entrance and houses all accessory drive gears. The vane type diffuser plate is attached to the forward end of the induction passage, where it shrouds the impeller. The supercharger rear housing, which is attached to the supercharger front housing by studs, forms the rear wall of the diffuser chamber. An automatic oil filter is attached to the left side of the rear housing. Two gun synchronizer impulse generator drives or substituting covers and a fuel pump are also mounted on the sides of this section. The impeller shaft rear oil seal assembly is supported in the steel sleeve which is shrunk in at the center of the diaphragm which forms the rear wall of the induction passage. Vent passages in the supercharger rear housing line up with similar passages in the supercharger front housing to equalize the rear section and crankcase pressures. Two holes equipped with combustion type cabin heater inlet connections are drilled in opposite sides of the supercharger rear housing adjacent to the forward flange. Provision has been made for the installation of a one-half inch, pipe tap, heater exhaust connection in the left rear face of the carburetor adapter. Cored drainage and suction passages communicate with similar passages in the supercharger front housing.

The supercharger rear housing cover is machined from a magnesium alloy casting in the form of a heavily ribbed flat plate, and is secured to the rear housing by machine screws and by studs, washers, nuts, and palnuts. The rear cover provides mounting pads for the two magnetos, generator, starter, oil pump, and dual accessory drive housing. Bushings in bosses on the front face of the cover form supports for the accessory drive gears and for the rear journal of the accessory drive and starter shaft. The cover is provided with the necessary pressure oil passages for lubrication of all the accessory drives. Provision is made for an oil tank vent connection at the upper center of the cover. An oil pressure gage connection is located adjacent to the oil tank vent flange, and a manifold pressure gage connection is provided at the top flange to the right of the rear cover center line.

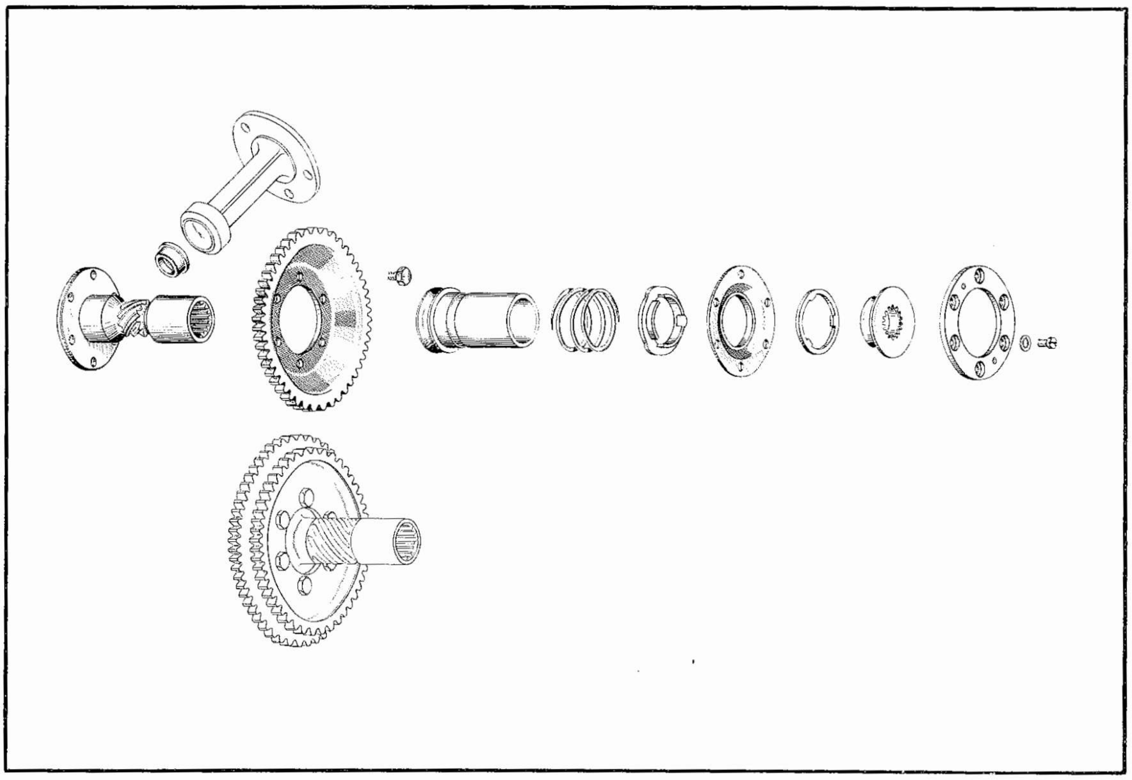


Accessory Drive and Starter Shaft

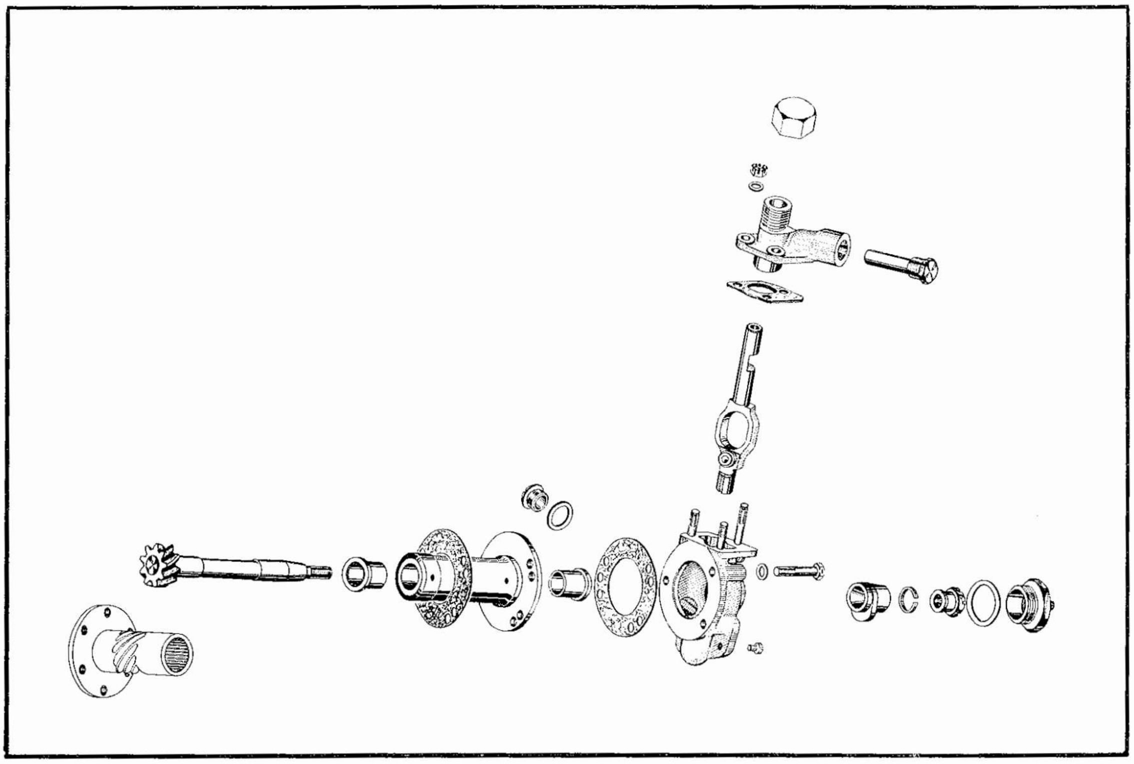
ACCESSORY DRIVE MECHANISM

The supercharger and all accessories are driven by a forged steel extension shaft from the rear end of the crankshaft, through an accessory drive gear which is attached to the shaft by means of a flexible spring drive. The accessory drive gear is machined and casehardened from an alloy steel forging. The accessory drive and starter shaft is splined at its front end with a coupling which is splined in turn into the rear of the crankshaft. The coupling is provided with a lock ring to insure that the coupling remains in place. The shaft is supported at its rear end by a bronze bushing in the rear cover. The rear end of the shaft has involute splines on its inside circumference which mate with a detachable starter dog. Holes are drilled in the journal wall section for the main oil feed into the center-drilled shaft. Two journals on the starter shaft bear on bushings within the hollow supercharger impeller shaft. The detachable starter dog is made of alloy steel. A hollow aluminum alloy spacer is installed between the starter dog and accessory drive and starter shaft at assembly, machined at assembly to a length which insures proper end clearance of the necessary drive shaft at the spherical oil seal ring which is supported on a pilot of the starter dog.

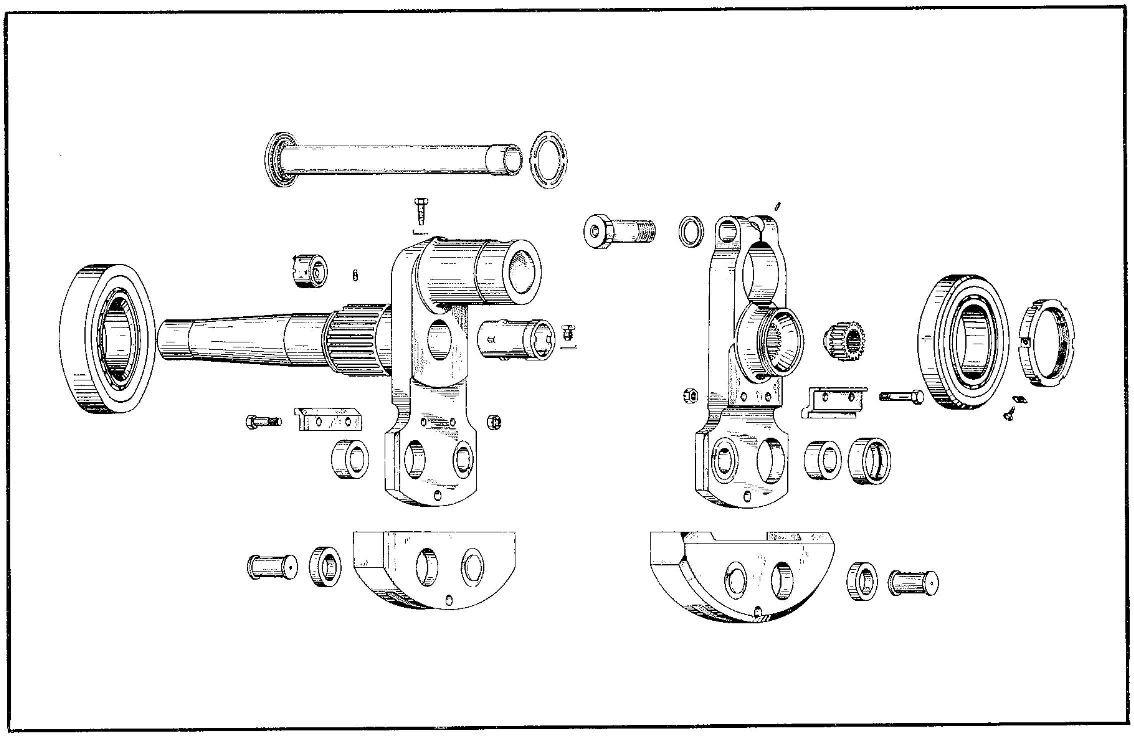
The accessory drive gear rotates as a unit with the starter shaft which is splined into the crankshaft. The starter, intermediate impeller, and generator drives are on the vertical center line of the supercharger rear cover. The magneto drives are located to the left and right above the starter shaft center line. The oil pump drive and the fuel pump and dual accessory drive are to the left and right of the generator drive immediately below the magneto drives. The accessory drive gear meshes with the pinion which is integral with the intermediate impeller drive gear. The intermediate impeller drive gear meshes with the gear on the end of the impeller shaft to drive the impeller. The pinion meshes with the generator drive gear. The accessory drive gear also meshes with the fuel pump and dual accessory drive gear and with the oil pump drive gear. The oil pump and the fuel pump and dual accessory drive gears each consist of two integral gears of different diameters. In each case the gear with the larger diameter meshes with the accessory drive gear. The shafts of these gears have internal splines which drive the dual accessory gear train and the oil pump respectively. The fuel pump and dual accessory drive gear shaft has a spiral gear machined into the middle to drive the fuel pump. The right magneto drive gear meshes with the fuel pump and



Magneto Drive Showing Gun Synchronizer Substituting Cover Plate



Gun Synchronizer Impulse Generator



Crankshaft

dual accessory drive gear on the small diameter, and the left magneto meshes with the oil pump drive gear on the small diameter. Gun synchronizer impulse generators, if used, are driven at right angles off spiral gears cut into the magneto drive shafts.

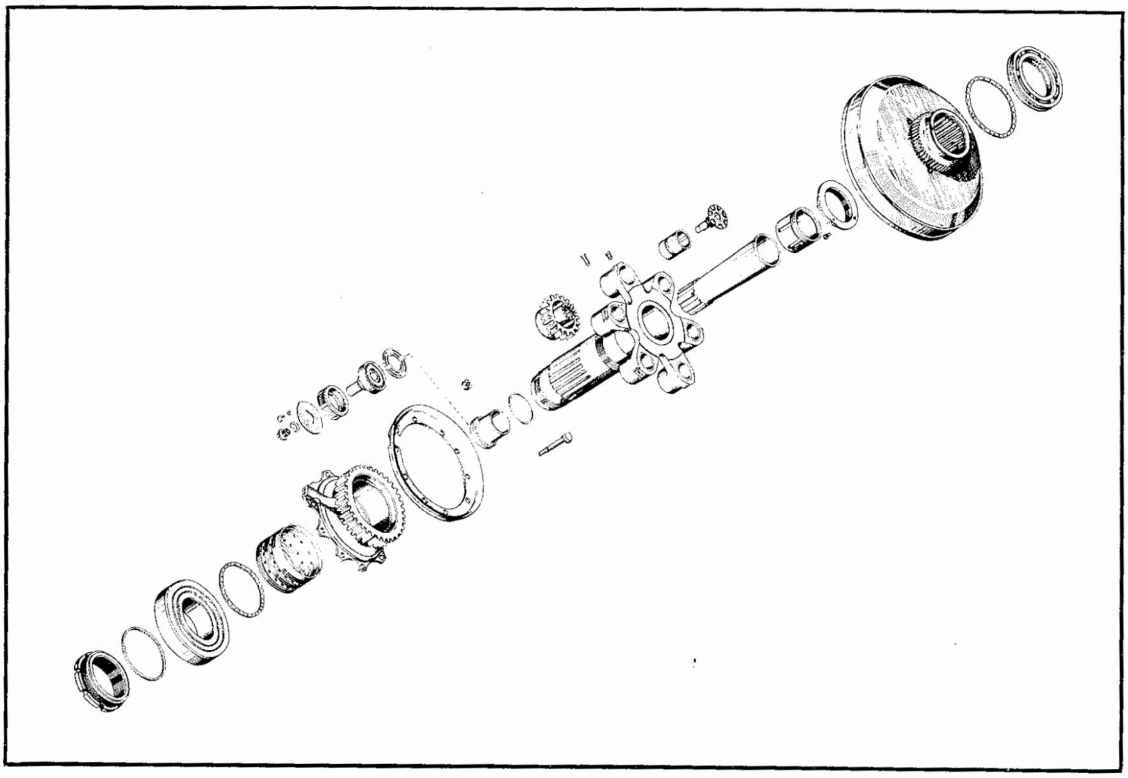
The generator and the oil pump drive gears are machined from alloy steel forgings with integral gear and shaft. The magneto drive and the fuel pump and dual accessory drive gear assemblies have forged steel gears attached to the flanged end of forged steel shafts by means of cap screws.

Bushings for the accessory and starter drive shaft, the generator drive shaft, and the fuel pump and dual accessory drive shaft are machined from cast bronze material. The accessory drive and starter shaft bushing is provided with three circumferential grooves and three slots to allow for the continuous flow of oil to the center of the accessory drive and starter shaft. The magneto, oil pump, and spare drive bushings are machined from aluminum alloy. Each gun synchronizer impulse generator drive shaft operates on two bushings of sintered material which are pressed into an aluminum alloy support. The supports are secured to the sides of the supercharger rear housing. On engines where gun synchronizers are not used, substituting covers with integral oil pressure plugs replace the gun synchronizer impulse generator drive shaft supports.

The various engine accessory drives, their locations, directions of rotation, and speeds are given on the installation drawing in the back of this Instruction Book, and additional drawings concerning a particular installation may be obtained upon request from the Wright Aeronautical Corporation, Service Division.

CRANKSHAFT The crankshaft is of two-piece design and is machined from alloy steel. The front section of the shaft includes the crankpin, the front crank cheek, front dynamic damper counterweight, the front main bearing journal, and the front extension. The rear section is composed of the rear crank cheek, the rear dynamic damper counterweight, and the crankshaft rear main bearing journal. The crankpin has one oil nozzle, located 18 deg. ahead of top center.

The upper end of the rear crank cheek is bored to receive the crankpin, and a hole is drilled and threaded to receive the crankpin clamping screw. A slot is provided to permit clamping action when the screw is tightened.



3:2 Reduction Gear

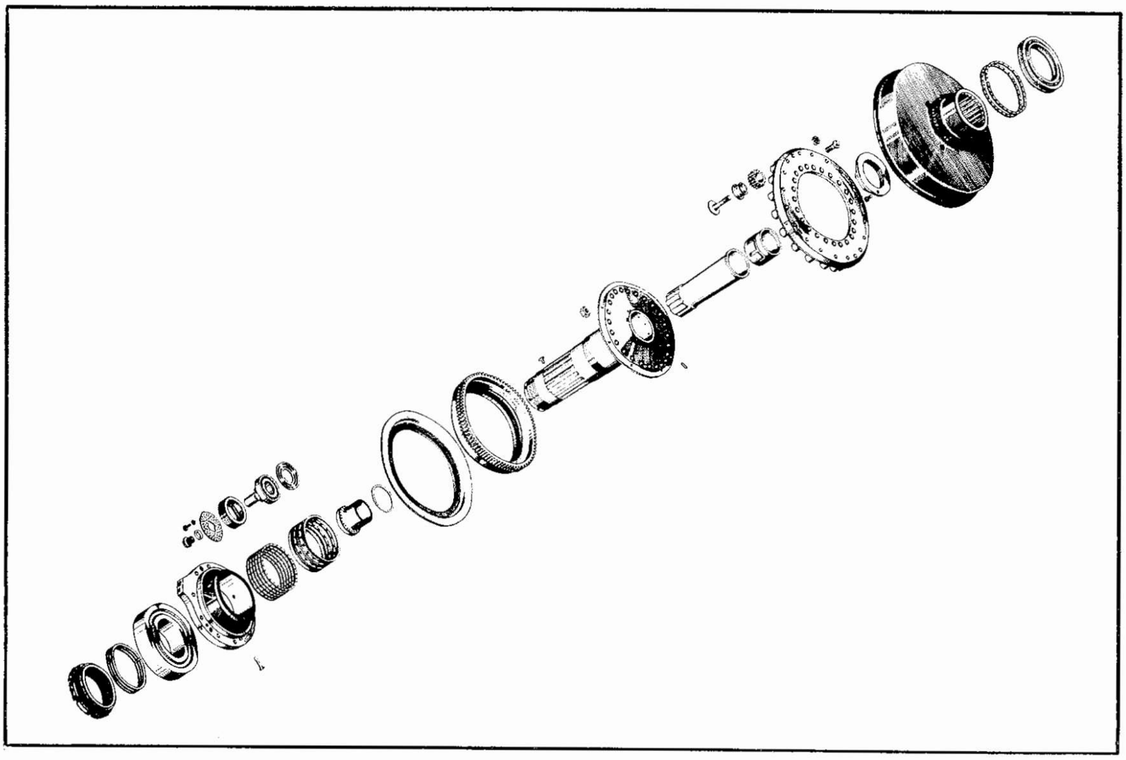
The general appearance of the dynamic damper is the same as that of the conventional counterweight. The units consist of two counterweights, each supported on two floating pins which pass through the extended portions of the crank cheeks. The bushings on the rear counterweight are of the floating type, installed in bronze bearings, and lubricated by two oil passages drilled in the rear crank cheek. The component parts of the dampers are locked to the crankshaft by stops bolted to the crank cheeks. These stops also limit the movement of the counterweights when the crankshaft is rotated by hand.

The crankpin and drive shaft are bored for lightness throughout, except at the rear end of the crankpin where a web is left to prevent distortion when the rear crank cheek is clamped in position. A plug is pressed into the front end of the crankpin bore and secured by a drilled cap screw, which also serves as an oil metering jet.

The crankshaft is supported in the crankcase by a roller bearing directly forward of the front crank cheek and by a roller bearing behind the rear crank cheek. Both bearings are of the demountable type, the front bearing incorporating sixteen rollers and the rear bearing eighteen rollers.

The crankshaft extends forward inside the propeller shaft and rides on two bushings, one at the front and one at the rear of the propeller shaft. Engines using crankshaft breathing incorporate a breather tube in the hollow crankshaft. The rear of the breather tube has an oil-tight fit in a support at the front crank cheek, while the flange at its propeller end seats on the propeller shaft front bushing. The annulus thus formed between the breather tube and the crankshaft acts as a reservoir for engine oil. The flange is drilled for two sets of holes to allow for the unrestricted flow of both hydro low and hydro high pressure oil to the propeller. A gasket, adapter, and retaining nut complete an oil-tight passage for the hydro oil to the propeller. A plug is used on the adapter to blank off the oil passages when a non-hydraulic propeller is used.

If crankshaft breathing is not used, this tube and its supports are not included in the assembly, and the front of the propeller shaft is sealed with a plug. Breathing then takes place through cored air passages in the supercharger front section to a vent on the top of the section.



16:9 Reduction Gear

PROPELLER SHAFT AND REDUCTION GEAR

The propeller shaft of alloy steel is a short straight shaft, hollow throughout its length. The shaft for the .666 reduction gear ratio engine has six pinion arms forged integrally at the rear end. The end of each arm is drilled and fitted with bronze bushings which carry the reduction gear pinions. The arms are drilled for lubrication of the bushings.

The shaft for the .5625 reduction gear ratio is slightly different. The rear end of the shaft has a large flange forged integral with the shaft. The flange is drilled for attaching bolts, and a carrier ring is fastened to it by means of nuts and bolts. The carrier ring incorporates 20 trunnions, each of which supports a bushing and pinion.

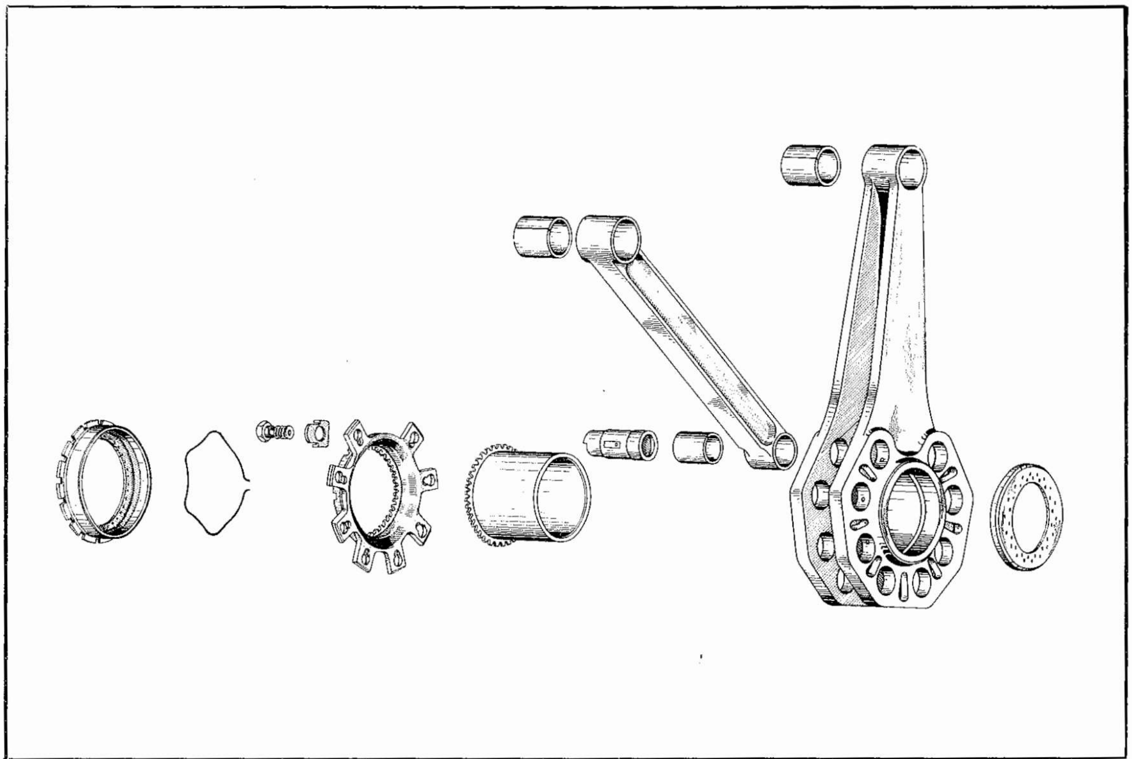
Each propeller shaft is threaded to receive the thrust nut, and the front end is splined to receive the propeller hub. Provision is made at the front end for a hydromatic propeller.

Reduction gearing is of the planetary type, consisting essentially of a reduction driving gear splined to the crankshaft, pinion gears mounted on the arms of the propeller shaft or on a carrier ring mounted on the propeller shaft, and a stationary gear secured to the front section. The pinion gears mesh with the reduction driving gear and the stationary gear in the front section.

The reduction driving gear is provided with a magneto timing scale ranging from 0 deg. to 35 deg., and scribe lines are provided to indicate the top dead center positions of the cylinders.

TORQUE INDICATOR

The Wright torque indicator measures the torque reaction on the stationary gear, sometimes referred to as the "sun" gear, of the propeller reduction gearing. The torque type stationary reduction gear is called the "stationary substituting gear," since it differs from the stationary gear used in non-torque indicator reduction gearing. This stationary substituting gear has a ball race on its inside circumference and a single integral torque arm. An adapter bolted to the crankcase front section has a similar ball race on its outside circumference. The stationary substituting gear is assembled to the adapter by means of a number of balls inserted between the races, permitting relative motion between the gear and the adapter and acting as an anti-friction device.



Master Rod Showing End Seal Disc, Articulated Rod, Lock Plate and Spacer

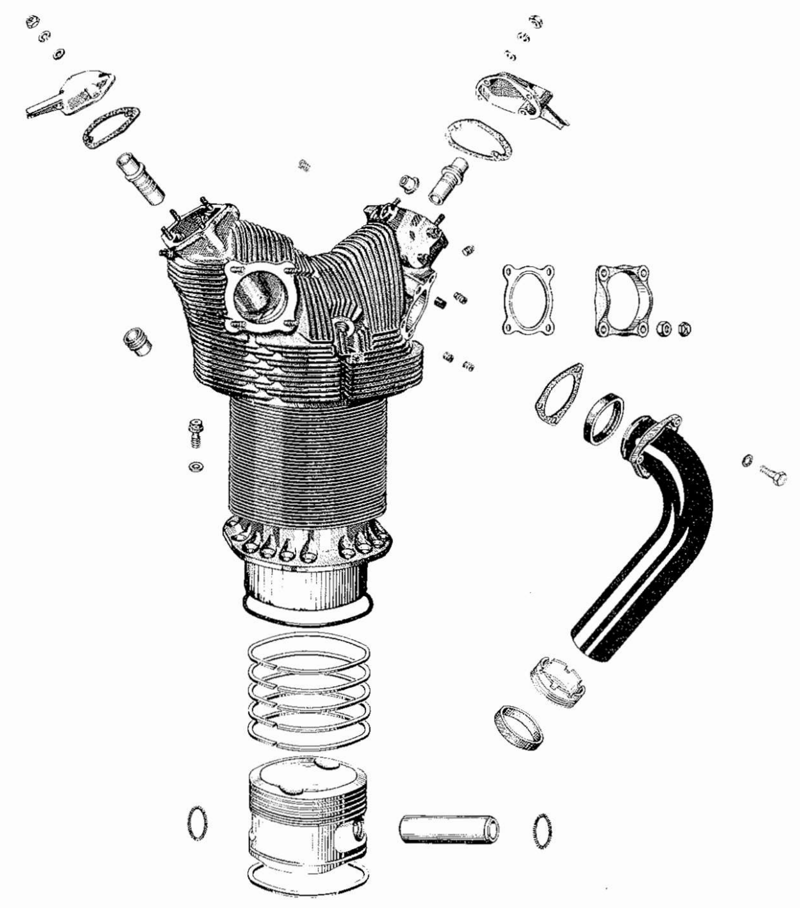
The outer end of the torque arm acts on a balancing valve enclosed in a conical valve housing which is bolted to the crankcase front section. The valve is actuated in one direction by the torque reaction of the stationary substituting gear and is balanced in the other direction by oil pressure on the valve head. The entire oil displacement of a small high pressure oil booster pump installed on the governor drive housing is conducted through drilled passages in the crankcase front section to the torque indicator valve housing. The stationary substituting gear is kept from turning by this oil pressure acting on the head of the valve, the force being transmitted through the torque arm. There is only slight relative motion between the stationary substituting gear and the adapter.

When the engine is operating, the torque reaction of the stationary substituting gear causes a slight outward movement of the valve and an increase in the oil pressure on the valve head. Oil drain slots or ports in the sleeve, in which the valve moves, are covered by the valve until the booster pump builds up sufficient oil pressure to overcome the torque reaction and produce a slight inward movement of the valve. This inward movement of the valve partly opens the metering slots. Oil escapes through these metering slots and is conducted to the crankcase. The oil pressure on the head of the valve decreases until the torque reaction is again just sufficient to overcome the oil pressure, and another slight outward movement of the valve is produced. This cycle is repeated until a point of equilibrium is reached.

An oil pressure gauge line is tapped into the valve housing cover at the valve head and is led to a special oil pressure gauge calibrated to indicate brake mean effective pressure.

CONNECTING RODS The connecting rod assembly consists of a master rod and eight articulated rods attached to the master rod by knuckle pins. The rods are fabricated from a special, I-section alloy steel forging, heat-treated for high strength and machined all over. Both the knuckle pin end and the piston pin end of the articulated rods are fitted with bronze bushings.

The web of the master rod shank is parallel with the crankpin axis, and the flanges of the shank blend smoothly into the knuckle pin flanges. A split type bronze bushing is expanded and spun into place in the piston pin end of the master rod. The crankpin end of the master rod



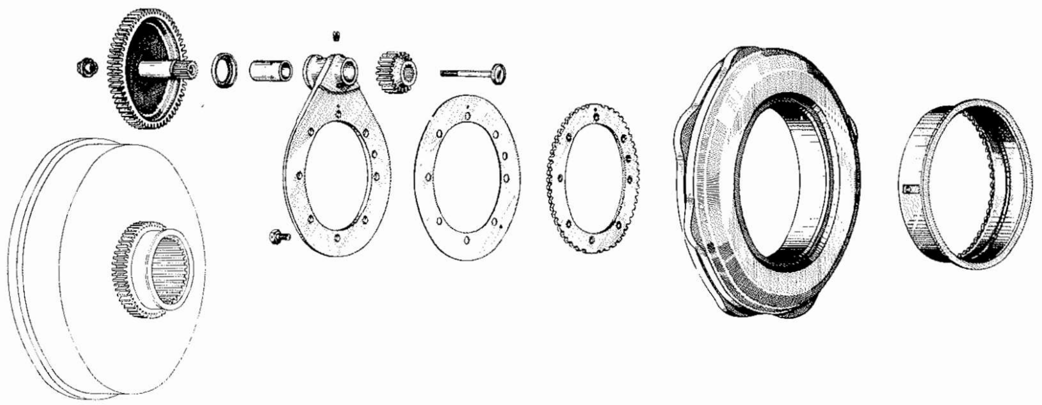
Cylinder, Intake Pipe, Piston and Piston Rings

is provided with a steel bushing lined with copper-lead bearing metal on its inside circumference and is also lead and indium plated for increased life.

A bearing end seal assembly is used on the master rod to improve the crankpin bearing lubrication by providing a seal against excessive oil leakage. The end seal assembly consists essentially of a steel knuckle pin lock plate, a spacer spring, and end seal discs for both the front and rear ends of the master rod bearing. The knuckle pin lock, which is bolted to the front end of the knuckle pins, has splines that mate with the forward end of the master rod bearing shell to prevent the latter from turning in the rod. A recess is machined into the front side of the knuckle pin lock plate for the spacer spring and end seal disc. A collar on this disc fits into the recess, and the spacer spring is located inside the collar. The front face of the disc is held snugly against the front crankcheek by the spacer spring to form an oil seal. The oil seal is completed by a carbon steel spacer, which fits over a boss on the rear side of the master rod.

The master rod operates in no. 1 cylinder in C9-GC series engines.

KNUCKLE PINS The knuckle pins are made of chrome alloy steel with nitrided bearing surfaces which have been finished by lapping and polishing. The front ends of the knuckle pins are drilled and threaded to receive cap screws which bolt the lock plate



Cam and Cam Drive

to the knuckle pins. Flat plate locks retain the cap screws. A lug on the forward end of the knuckle pin engages with the edge of the lock plate to prevent rotation of the pin in the master rod. The hollow center of the pin receives oil through passages in the lock plate and lock screw, and the oil is fed to each articulated rod bushing through two drilled holes in each knuckle pin.

PISTON PINS Piston pins are made from alloy steel with a casehardened bearing surface. They are of tubular design, ground smooth internally and externally, and lapped on the outside circumference to provide a finished bearing surface. Coil spring type retainers at each end of the piston pin lock it in place in the piston.

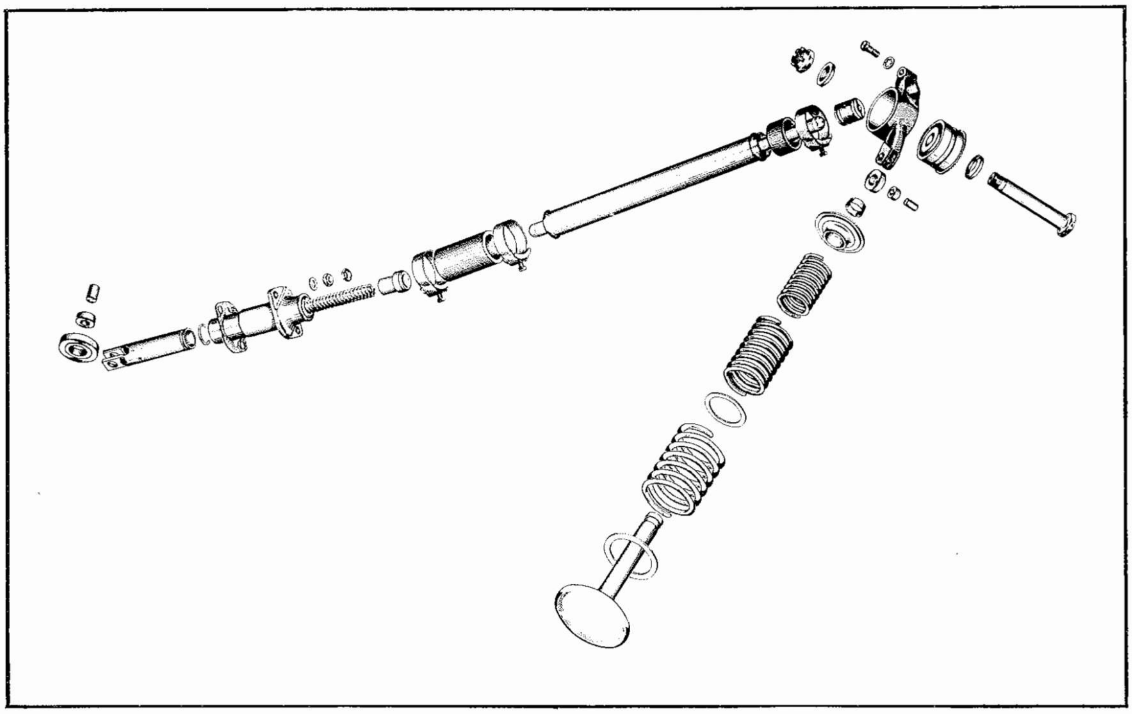
PISTONS AND RINGS The pistons are the full trunk type, machined from aluminum alloy forgings. Fins are machined on the inside of the skirt on the thrust and anti thrust sides. The pistons are recessed on top, to provide adequate valve head clearance.

The piston assemblies are of the standard "Uniflow" type. The top three ring grooves are slightly tapered. Three identical wedge type rings are assembled in the grooves. The three lower rings and grooves are of rectangular cross section with the bottom ring inverted, so that it pumps oil along the cylinder wall. Grooves 4 and 5 are drilled for oil drain holes.

VALVE OPERATING MECHANISM The operation of the valves is accomplished by means of a cam which is located in the crankcase front section and consists of a hardened steel ring with two sets of cam lobes on its outside circumference. This ring is mounted on the hub which is integral with the crankcase main section front half. An intermediate cam drive gear, intermediate governor drive gear, and a cam drive pinion are mounted on a bracket which is secured to the hub with six cap screws. The driving power for these gears is taken from the cam drive which is machined on the hub of the reduction drive gear. The cam drive gear bracket is drilled to provide pressure lubrication to the bushing.

The cam lobes acting on the cam follower rollers, or valve tappets, actuate the push rods, and they in turn operate the rocker arms which open the valves.

The tappets or cam followers and the tappet guides are evenly spaced around the outside



Valve Mechanism

wall of the crankcase front section. The tappets are of hardened steel and are given a close sliding fit in the guides to prevent oil leakage. The tappet and guide assembly is held together by a circlet which fits into a groove machined into the push rod end of the tappet. A steel cup or socket is located in the push rod end of the valve tappet. For lubrication purposes, this socket is given a close sliding fit in the tappet and is held against the push rod ball end by a coil spring inside of the tappet. The tappet assemblies located above the horizontal center line of the engine are lubricated by pressure oil. The remainder of the tappets are lubricated by gravity oil. The tappet guides are slotted on the forward side of the push rod end to permit the removal of the push rods without removing the rocker arms. The roller end of the tappet is slotted to receive the cam follower roller which rotates on a floating pin.

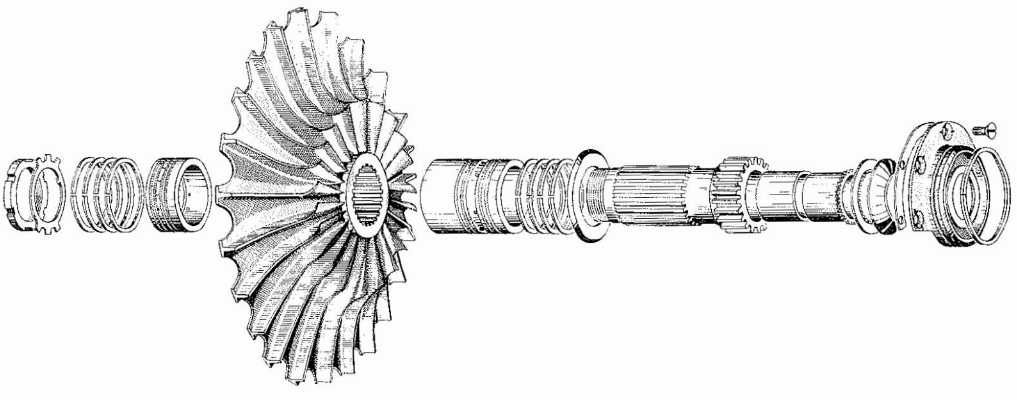
The push rods are of heat-treated, seamless steel tubing with hardened steel ball ends pressed into each end. The push rod housings are of annealed, seamless dural tubing. Each housing is connected to the tappet guide and to the connection at the rocker box with oil-tight hose connections.

The rocker arms are I-section and are machined from steel forgings. They are mounted on double roller bearings, the inner races of which are clamped in the rocker box by a through bolt. The valve end of the rocker arm is forked to carry a roller operating on a hub and a pin riveted in the arm. The push rod end of the rocker arm is provided with a tappet clearance adjusting screw and an adjusting screw lock screw.

VALVES AND VALVE SPRINGS The intake valves are of the tulip type and the exhaust valves are of the mushroom type. Both are machined from forgings of heat resisting steel. Valve face angles are 44 deg. 45 min. to 45 deg. 0 min. for both intake and exhaust.

The exhaust valve is hollow and contains a cooling medium, while the intake valve stem is smaller in diameter and of solid cross section. A stellite seat is welded to the exhaust valve to improve the wearing qualities.

Each valve is fitted with three concentric coil springs. The intake and exhaust valve springs are interchangeable. The inner spring seats on the shoulder of the valve guide, while the intermediate and outer springs seat on steel washers which rest on machined surfaces in the cylinder head. A shouldered washer is provided at the



Supercharger Impeller and Impeller Shaft

outer end of the springs and is locked at the valve tip by a tapered, split lock ring.

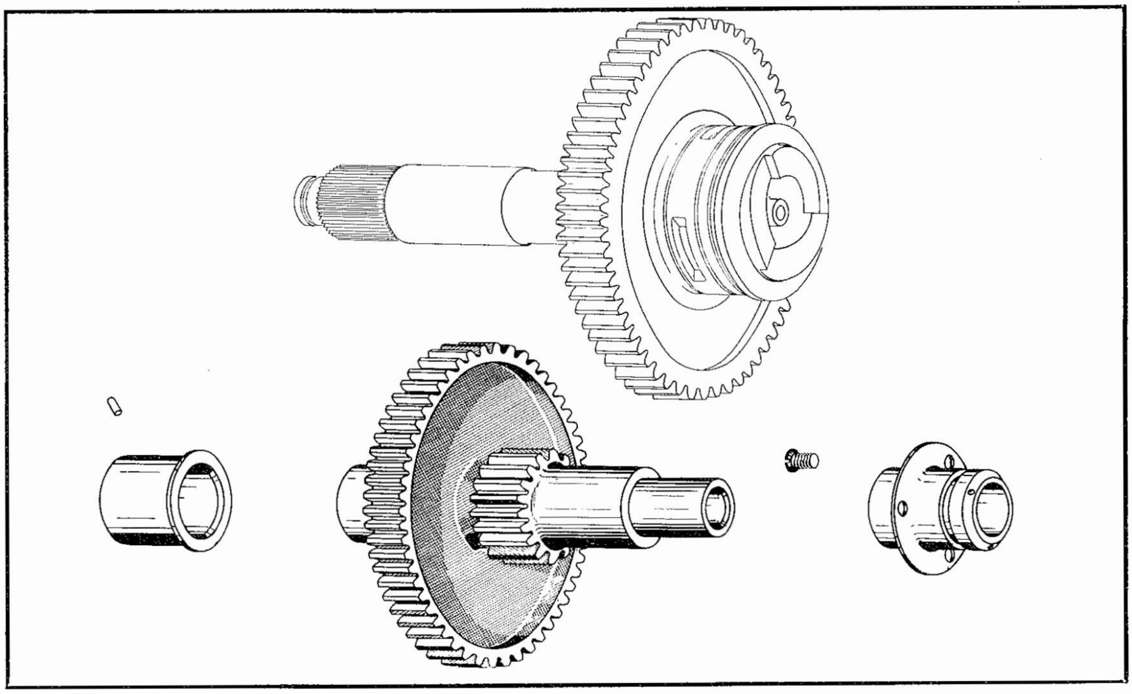
SUPERCHARGER The supercharger, which is of the centrifugal type, consists of an impeller or blower, diffuser plate, and distribution chamber. The impeller is machined from a duralumin forging. It is mounted on a hollow steel shaft with one plain bushing pressed inside each end. The impeller shaft is concentric with the accessory drive and starter shaft which provides journals for the two internal plain bushings in the impeller shaft.

The distribution chamber, an annular passage in the supercharger front housing, surrounds the impeller and the diffuser plate. The intake pipes are attached to this chamber through ports radial to its circumference.

The impeller shaft is located axially by a flat thrust washer and a spherical thrust ring at the rear of the impeller shaft gear and by a steel retainer attached to the supercharger rear housing. A bronze washer is provided in front of the impeller shaft gear and a laminated shim beneath the steel retainer attaching flange for end clearance adjustment. The impeller operates with the inlet side facing the rear of the engine.

Around the impeller shaft in the supercharger front housing is an oil sleeve with piston ring type seals which provide an oil seal to prevent the supercharger from drawing oil out of the crankcase. An annular groove at the midpoint of this sleeve is connected through a blank impeller spline to the groove of a similar oil seal housed in the supercharger rear section. A vent from the rear sleeve to the atmosphere breaks the suction and prevents the leakage of oil through these seals to the supercharger.

A drain passage is provided from the lower rear portion of the supercharger inlet chamber out through the supercharger rear housing to prevent the accumulation of excess fuel. A check valve stops air from being drawn in through this passage. A restricted air bleed is provided, however, through a small diameter tube that leads up through the drain passage to the impeller inlet area. During engine operation any fuel that runs down the walls of the supercharger inlet passage collects in the drain passage on top of the check valve which is held closed by the suction of the supercharger. Four holes are provided in the air bleed tube to permit the fuel to be drawn in and atomized for re-delivery to the impeller.



Single-Speed Supercharger Drive

SINGLE-SPEED SUPERCHARGER The single-speed supercharger drive unit consists of an impeller drive and pinion gear (7.0:1 ratio) which rotates in a bushing in the supercharger housing rear cover at one end and another bushing in the supercharger rear housing web at the other end.

The drive for the impeller is from the accessory drive gear to the impeller drive and pinion gear to the impeller gear.

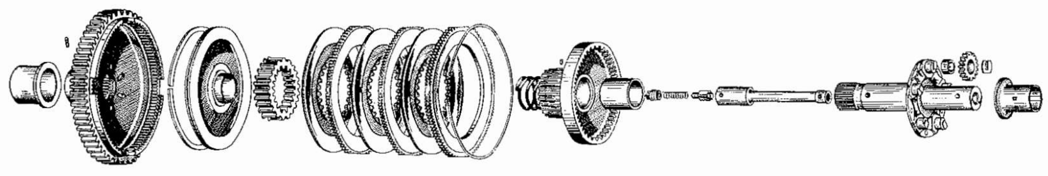
TWO-SPEED SUPERCHARGER DRIVE (PLATE CLUTCH TYPE) The two-speed supercharger drive plate clutch unit, available on some C9-GC models, consists essentially of a high-speed ratio drive supplemented by a planetary gear reduction system which, when engaged, produces the low-speed ratio drive. A plate clutch is housed in the supercharger rear housing cover to effect the low ratio drive while a second plate clutch, housed in the impeller drive gear, actuates the high ratio drive. The high ratio clutch revolves with the impeller drive gear while the low ratio clutch remains stationary in the supercharger rear housing cover. The speed change is obtained by means of a manually operated control valve which regulates the flow of oil to either clutch, thereby engaging that particular clutch.

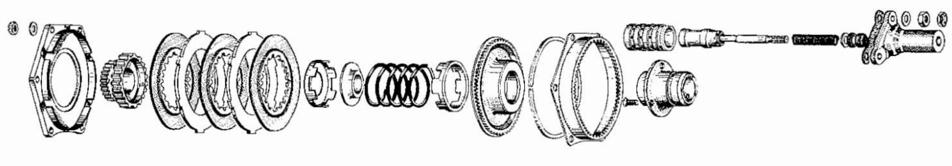
The two-speed control valve assembly, which is attached to the supercharger rear housing cover, is a push-pull piston type selector valve. The selector valve is held in the LOW ratio position by the action of a built-in spring and in the HIGH ratio position by manual control in the cockpit.

The operation of the drive through the low ratio gear is as follows:

When the manual control is placed in the low-speed position, the two-speed control valve is in the extreme forward position. Engine oil under pressure is led from a passage in the rear cover, through the control valve, and into a chamber behind the low-speed clutch piston by way of another drilled passage.

The low-speed clutch piston is moved forward by the oil pressure which in turn presses the clutch plates and discs together. As the clutch plates and discs engage, the low-speed planetary sun gear becomes stationary, thus obtaining the low ratio through the planetary gear drive. At the same time the high ratio clutch plates and discs are disengaged by a coiled spring built into the clutch. In low ratio, therefore, the drive is from the accessory drive shaft gear to the small bell-shaped intermediate driving gear, through this gear to the five planetary pinion





Two-Speed Plate Clutch Supercharger Drive

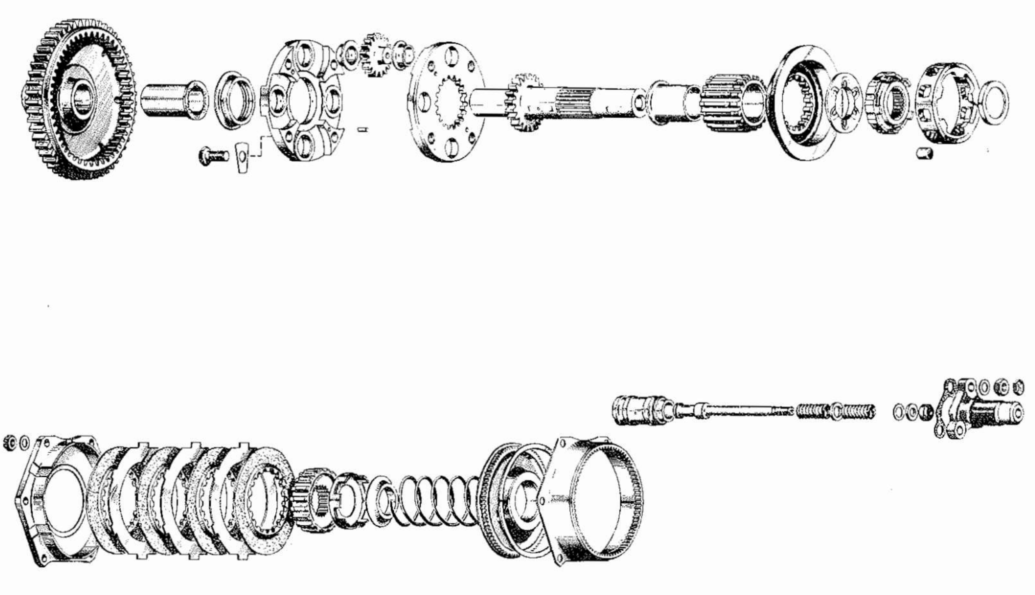
gears and intermediate impeller drive shaft, on which the pinion gears are mounted; through this shaft, which is splined to the impeller drive gear at the forward end, and thence to the impeller shaft gear.

The high gear ratio is obtained by means of engine oil pressure in the following manner: With the control valve in the extreme rearward position, engine oil passes through the control valve from a drilled passage in the rear cover; then through another drilled passage in the cover into the hollow intermediate impeller drive shaft, where it passes through a check valve in the forward end of the shaft; then through drilled holes in the shaft and into the chamber behind the high-speed clutch piston. The piston moves toward the rear of the engine under the action of the oil pressure, thus engaging the clutch plates and discs and locking the bell-shaped, intermediate impeller drive gear to the impeller drive gear through a splined adapter in the high ratio clutch.

Changing the position of the selector valve from low ratio to high ratio not only supplies oil to operate the high ratio clutch but also cuts off the oil flow to the low ratio clutch, at which time the action of the spring built into the low ratio clutch releases clutch plates, discs, and piston. As the piston moves toward the rear of the engine, oil in the chamber behind the piston is forced out through a passage in the rear cover and drains into the supercharger rear housing. The planetary sun gear is now disengaged, thus permitting the planetary reduction gears to turn freely and the low-speed clutch becomes inoperative.

In high ratio the drive is from the accessory drive gear to the propeller end of the bell-shaped intermediate impeller drive gear, from the intermediate impeller drive gear through the high ratio clutch and gear to the impeller shaft gear and shaft.

TWO-SPEED SUPERCHARGER DRIVE (ROLLER CLUTCH TYPE) The two-speed, roller clutch supercharger drive consists of a roller and cam clutch in low ratio and a plate clutch in high ratio. The essential difference between this and the earlier two-speed double hydraulic plate clutch is the use of a stationary plate clutch in high-speed ratio, eliminating the rotating plate clutch. The drive in low-speed ratio is accomplished through a roller and cam assembly instead of a planetary pinion drive.



Two-Speed Roller Clutch Supercharger Drive

The roller clutch in the low-speed ratio supercharger drive consists of a steel cam which acts as the inner race for ten steel rollers. The low-speed impeller drive cam is splined on its inside circumference to the intermediate impeller drive shaft and the rollers are held in place on the outside circumference of the cam by a bronze cage and a steel retainer. The steel retainer splines on its propeller end to the anti-propeller end of the intermediate impeller drive gear. In turn, the intermediate impeller drive gear splines on its propeller end to the inside circumference of the rear half of the intermediate impeller drive pinion cage.

The intermediate impeller drive gear and bushing ride on a journal at the approximate center of the intermediate impeller drive shaft. The four intermediate, impeller drive planetary pinion gears in the intermediate impeller drive pinion cage mesh with the sun gear, which is integral with the intermediate impeller drive shaft, and with the internal teeth of the impeller drive gear. The impeller drive gear and bushing ride on a journal at the propeller end of the intermediate impeller drive shaft. The outside circumference of the impeller drive gear journal rides in a bushing in the supercharger rear housing, and the external teeth of the gear mesh with the gear teeth on the anti-propeller end of the impeller shaft.

The hydraulic multi-plate clutch for the high-speed ratio drive is located at the anti-propeller end of the intermediate impeller drive shaft in the supercharger rear housing cover.

The high-speed piston seats on the outside circumference of a bushing which is pressed into the rear cover. The piston ring seats against the high-speed impeller drive clutch sleeve, which is inserted in the rear cover, and the splines on the outside circumference of the piston mate with those on the inside circumference of the high-speed, impeller drive clutch sleeve. Forward of the piston is a high-speed clutch disc, which is splined on its inside circumference to the intermediate impeller drive clutch adapter, which in turn is splined to the intermediate impeller drive shaft. Directly forward of the high-speed clutch disc is a high-speed clutch plate which splines on its outside circumference to six notches in the high-speed, impeller drive clutch housing. There are four clutch discs and three clutch plates alternately arranged in the above manner. Forward of the last clutch disc is the high-speed, impeller drive clutch housing. The housing is attached to the supercharger rear housing cover with six wash-

ers, nuts, and cotter pins, thus retaining the high speed clutch assembly.

Pressing against the forward face of the high speed piston is the high-speed, clutch release spring. The propeller end of this spring seats on the high-speed clutch spacer. The purpose of this spring is to disengage the piston, plates, and discs when the oil pressure is released and the high-speed clutch is not in operation.

The roller clutch, two-speed supercharger drive assembly operates either in high- or low-speed ratio, there being no neutral position in which both the high and low-speed ratio drives are disengaged at the same time, and no position in which they are both engaged at the same time.

In either supercharger drive ratio, the primary gear train is from the accessory drive and starter shaft gear to the intermediate impeller drive gear, thence through either the low- or high-speed clutch to the impeller drive gear, and then to the impeller shaft.

In low-speed ratio operation, the drive is as follows: From the accessory drive and starter shaft gear to the intermediate impeller drive gear which is splined on its anti-propeller end to the roller retainer. Because of the inertia force exerted by the impeller on the impeller drive gear, the intermediate impeller drive pinions rotate, and in turn, cause the intermediate impeller drive shaft and integral sun gear to rotate. The intermediate impeller drive shaft turns the roller clutch cam in the same direction and at a higher speed than the roller retainer. This relative difference in speed between the cam and the roller retainer causes the rollers to rise up on the lobes of the cam and lock the roller retainer, the rollers, and cam as a single unit. Because the roller clutch assembly is now operating as a single unit, the intermediate impeller drive pinions, the sun gear, and the impeller driving gear must also operate as a unit. The drive for the low speed ratio clutch is, therefore, operating directly from the accessory drive and starter shaft gear, through the intermediate impeller drive gear to the impeller drive gear, and thence to the impeller shaft. This results in the desired impeller to crankshaft speed ratio for low supercharger operation.

In high-speed ratio operation the drive is as follows: From the accessory drive and starter shaft gear to the intermediate impeller drive gear, which is splined on its propeller end to the rear half of the intermediate impeller drive pinion cage and on its anti-propeller end to the roller retainer.

Because of engine oil pressure, which is distributed to the chamber behind the high-speed piston by the oil control valve, the piston moves forward compressing the high-speed clutch release spring and locks the clutch discs, which are splined indirectly to the intermediate impeller drive shaft, hence to the stationary clutch plates. With the intermediate impeller drive shaft and the low-speed impeller drive cam held stationary, the roller retainer rotates around the cam, thus freeing the rollers and disengaging the low-speed ratio clutch. This results in the intermediate impeller drive pinion gears revolving around the intermediate impeller drive shaft gear and driving the impeller drive gear, which in turn, drives the impeller shaft.

As the pinion gears drive the impeller drive gear through its internal teeth, and the impeller drive gear in turn drives the impeller shaft from its external teeth, the desired impeller to crankshaft speed ratio for high-speed supercharger clutch operation is obtained.

Selection of impeller to crankshaft speed ratios is accomplished by means of a push-pull oil control valve. The oil control valve operates inside the oil control valve sleeve which is pressed into the rear supercharger housing cover. Concentric about the valve stem, and inside the oil control valve housing, are two springs, separated by a washer which seats against a spacer in the housing and limits the movement of the valve. The oil control valve for the roller clutch assembly is placed in the extreme forward or "in" position for low-speed ratio drive, and in the extreme rearward or "out" position for high-speed ratio drive.

The operating oil for the high-speed ratio drive is supplied through a drilled passage in the rear cover to an annulus around the control valve sleeve.

When the low-speed ratio drive is in operation, no operating oil pressure is necessary. The low-speed ratio drive is operated by the roller clutch assembly as previously described. However, when the high-speed ratio drive is in operation, oil pressure is required to engage the high-speed clutch piston, discs, and plates. This pressure oil is obtained by moving the oil control valve to the rearward or "out" position. This allows the engine pressure oil to flow around the annulus cut in the oil control valve to a drilled passage in the oil control valve

sleeve and through a mating drilled passage in the rear cover to the chamber behind the high-speed piston.

When the oil control valve is shifted back to the low-speed ratio drive position, it blanks off the pressure oil passages to the chamber behind the high-speed piston and opens drain passages through the valve and the rear cover, thus releasing the pressure oil in the chamber behind the high-speed piston. This releases the piston, discs, and plates with the aid of the high-speed clutch release spring.

LUBRICATION The lubrication system is of the full pressure type except for the cylinder walls, piston pins, crankshaft main bearings, and propeller shaft thrust bearing, all of which are lubricated by splash. Oil is carried in an external tank not furnished with the engine but with the plane. The oil is drawn from the supply tank by a pump mounted on the left side of the rear cover. The oil pump is provided with a spring loaded piston type pressure relief valve which lifts from its seat, when the desired pressure is exceeded, to bypass oil to the inlet side of the oil pump thus maintaining the desired pressure. Pressure regulation is accomplished by turning the adjusting screw which increases or decreases the tension in the pressure relief valve spring. The pressure pump discharges the oil into a filter inserted into the left side of the supercharger rear section.

The oil is led directly from the filter to an annular groove machined in the accessory drive and starter shaft bushing bore in the rear cover. The rear cover is cast with four ribbed sections extending radially from the accessory drive and starter shaft supporting boss. These sections are drilled to communicate with the annular groove surrounding the accessory drive and starter shaft bushing. A tube conducts oil from the top of this annulus to a pressure gauge connection.

The two upper drilled passages supply oil to a groove around the outside circumference of each magneto shaft bushing. The upper portion of each magneto shaft bushing is milled away for the installation of a gun synchronizer support, uncovering the groove in two locations through which the oil issues to lubricate the gun synchronizer and the inside circumference of the magneto shaft bushing. Provision is made in the gun synchronizer support for oil drainage back into the rear housing.

The lower right-hand drilled passage provides oil to a groove around the outside circumference of the fuel pump and dual accessory drive shaft bushing. This bushing is milled away in a similar manner to the magneto bushings to accommodate the fuel pump drive shaft support, uncovering the oil groove at two points. The oil issuing from these two openings lubricates the inside circumference of the fuel pump and dual accessory drive shaft bushing. The fuel pump drive shaft supporting bushings are of sintered material and do not require pressure lubrication. Any oil leakage past the supporting bushings is drained into the supercharger rear housing through holes drilled in the support. A passage is drilled angularly through the supercharger rear housing cover from rear to front at the spare drive mounting pad, communicating with an oil groove opening at the spare drive shaft bushing. Oil under pressure travels through this passage to lubricate the dual accessory drive gear box and the accessories requiring engine oil for lubrication.

The lower left-hand passage is drilled slightly larger than the other because, in addition to conducting the oil to the oil pump shaft bushing, it communicates with other drilled passages to supply oil to the impeller drive, either single-speed or two-speed, and to the generator drive shaft bushing.

Oil from the drilled pressure passage enters the inside of the oil pump shaft bushing through a hole drilled in a groove extending around the outside circumference of the bushing at its front end. A longitudinal groove inside the bushing distributes the oil along its length. A circumferential groove and drilled hole are provided at both ends of the bushing so that it cannot be installed incorrectly.

A ribbed section between the oil pump drive shaft supporting boss and the generator drive shaft supporting boss forms an integral part of the front face of the supercharger rear housing cover casting. A branch passage is drilled through this section intersecting the oil pressure passage to the oil pump drive shaft bushing. Oil is supplied to a groove in the outside circumference of the generator shaft bushing through this branch passage. The groove is drilled with four holes for lubricating the inside of the bushing. The supercharger rear housing cover is drilled from rear to front at the left hand side of the generator mounting pad to communicate with the branch oil pressure passage for supplying the generator, or accessory, with engine oil if desired.

On engines equipped with the two-speed plate-type supercharger drive, the control valve assembly, which supplies the oil for the operation and lubrication of the two-speed supercharger drive, receives its supply from a passage drilled in the supercharger rear housing cover to intersect the pressure oil passage adjacent to the oil pump drive shaft supporting boss. The oil is distributed from the control valve chamber to the two-speed clutch unit through drilled passages in the supercharger rear housing cover. The valve admits the lubricating oil to a groove in the intermediate impeller drive shaft bushing in the rear cover. The steel portion of the bushing is drilled with longitudinal passages to bring the oil forward to an annulus inside the bushing, where it is distributed by means of a flat on the shaft, and whence it enters the inside of the hollow shaft through a drilled passage. A steel sleeve known as the oil distributor plug is pressed into the hollow shaft to separate the lubricating oil from the operating oil which is used to operate the high-speed ratio clutch. The intermediate impeller drive shaft is drilled to provide lubrication to each of the five pinion gear supporting journals as well as the journals which support the bell-shaped gear and the planetary sun gear. A longitudinal groove through this pressed-in oil distributor plug allows the lubricating oil to reach the front supporting bushing, where it is distributed by a flat in the journal of the impeller drive gear.

Ample drainage facilities are provided to prevent any tendency of the lubricating oil to operate one clutch with the other one engaged. These drainage locations are shown by red arrows on the clutch section of the lubrication chart.

When the roller clutch is used, the lubricating oil for the supercharger clutch drives is supplied from the same annulus around the oil control valve sleeve which supplies the operating oil. Some of the oil flows through a drilled passage from the annulus to the rear end of the intermediate impeller drive shaft rear bushing and through the hollow shaft. At the approximate center of the intermediate impeller drive shaft, some of the oil flows through three drilled passages to lubricate the intermediate impeller drive gear bushing and journal. The remaining oil continues through the hollow shaft and out the propeller end to lubricate the front bushing and journal and the bushing and journal of the impeller drive gear. This oil is also led through drilled passages in the front intermediate impeller drive pinion cage to lubricate the intermediate impeller drive pinions and bushings.

Single-speed engines are equipped with a control valve substituting cover which is provided with oil grooves to connect the supply passage to the intermediate impeller drive gear shaft.

The accessory drive gears run in a continuous spray of oil due to the fact that oil is constantly being forced out of the ends of their shaft supporting bushings. To prevent external oil leakage at the rear end of the generator and magneto drive shafts, the shafts are equipped with spring loaded oil seals. Instead of spring loading, the accessory drive and starter shaft uses the oil pressure on the starter coupling to effect the seal.

The supercharger rear housing cover is drilled at the base of a recess behind each accessory drive shaft bushing to drain the surplus oil into the rear supercharger housing. The magneto, oil pump, and spare drive shaft recesses have one drain hole each. The generator shaft recess has three drain holes, while the starter and accessory drive shaft recess has two internal drain holes and provision for one external drain on the lower right-hand side of its raised mounting pad.

The oil in the accessory drive and starter shaft bushing is led through holes to the hollow center of the accessory drive and starter shaft. A hole drilled through the shaft leads lubricating oil out to the annulus formed between the accessory drive and starter shaft and the impeller shaft.

From the accessory drive and starter shaft, the oil is led to a recess in the rear crank cheek and from this recess through a drilled passage in the rear crank cheek to the hollow center of the crankpin. The sludge eliminating oil nozzle leads some of this oil to the master rod bearing. The oil is led from the front end of the master rod bearing to an annulus in the master rod bearing end seal and through a series of drilled passages in the knuckle pin locking plate to the center of each knuckle pin. The knuckle pins each have two drilled holes which lead oil to the knuckle pin bushings.

Splash lubrication of the pistons and cylinder walls is effected by a crankpin oil metering screw in the front crank cheek. However, some of the early engines are equipped with a smaller oil jet in the metering screw which is supplemented by another oil jet drilled in the top of

the crankpin adjacent to the rear crank cheek. The oil leakage from the knuckle pin bushings also aids in lubricating the cylinder walls and pistons. Two drilled passages in the rear crank cheek supply oil to the floating damper pin bushings.

A drilled passage in the front crank cheek leads oil from the crankpin to the center of the crankshaft. This hollow shaft acts as a header from which the lubrication passages in the front section are tapped. If a crankshaft breather tube is used in the engine, the rear tube support is so constructed that the oil flows readily into the annulus between the breather tube and the crankshaft, and this annulus serves as the header.

The rear hole in the crankshaft front extension leads oil to an annulus in the inside circumference of the reduction driving gear spacer. The spacer and front main bearing ring are drilled to carry oil to an annulus formed between the front main bearing ring and the inside circumference of the hub on the crankcase main section front half. From there, oil is led through drilled holes in the hub and cam bearing ring to the surface of the cam bearing ring. A hole drilled in the cam drive gear bracket communicates with the upper hole in the boss to supply oil to the cam drive gear bushing. Leakage from these bushings lubricates the cam gear teeth.

The remaining hole in the crankshaft leads oil to an annulus formed between the propeller shaft rear bushing and the propeller shaft and to the annulus between the two rear sets of oil seal rings on the thrust bearing spacer. From the annulus in the propeller shaft rear bushing, oil is led to a hole drilled in each of the six spider arms on the 3:2 ratio propeller shaft. The oil is fed through these passages into a groove in each spider arm bushing. From these grooves the oil passes through drilled holes in the pinions into the annulus formed between the inside of the pinion and the pinion lock nut. Another drilled hole leads oil from this annulus back to the bushing in the spider arm. Leakage from the bushings lubricates the reduction driving gear teeth.

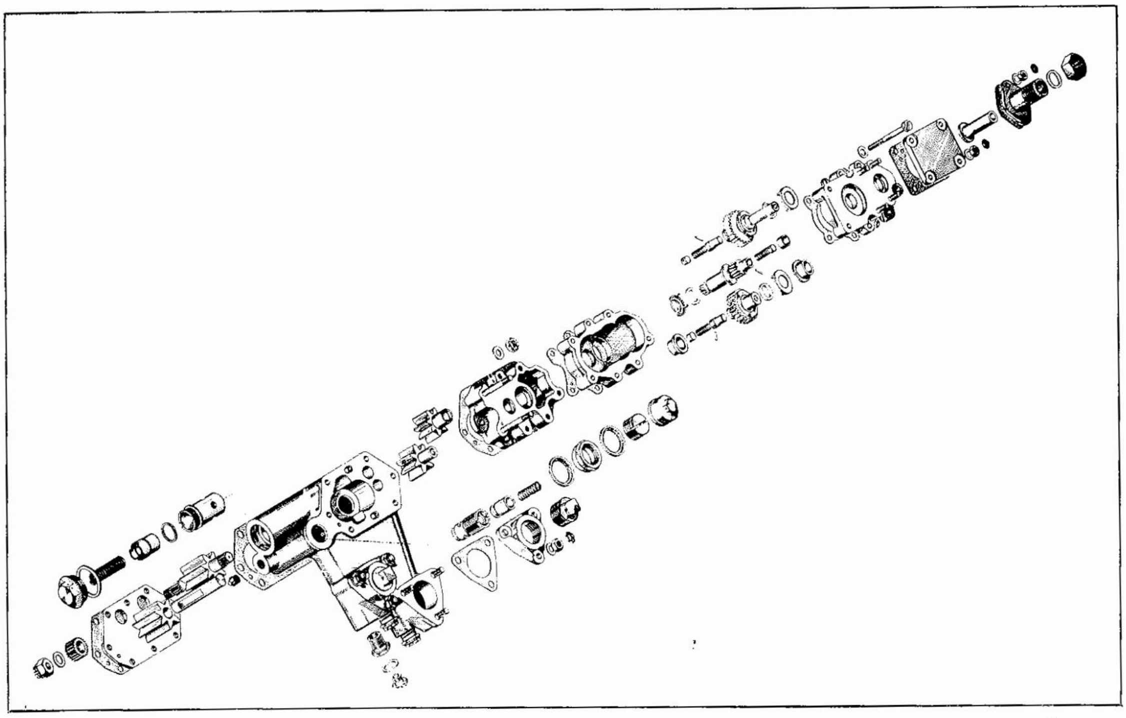
The 16:9 ratio propeller shaft employs a slightly different system. The flanged end of the propeller shaft has eight drilled passages leading from the supply groove in the propeller shaft rear bushing to the annulus formed between the flange and the trunnion carrier ring. Drilled passages in the carrier ring connect the center of each trunnion to this annulus. The pinion lock bolts have a reduced section in the center, forming an annulus between the bolt and the trunnion inside circumference. Two drilled holes in the trunnions convey oil to the inside of the bushing. Leakage from the bushings lubricates the reduction driving gear teeth. A small hole is drilled through the propeller shaft flange from front to rear, connecting with the carrier ring annulus. This hole supplies a constant spray of oil to the stationary reduction gear teeth.

The oil, which was described as being led to the annulus between the two rear sets of oil seal rings on the thrust bearing spacer, is conducted through drilled passages in the stationary reduction gear support and the front section to the governor mounting pad. This is the low, or engine, pressure governor oil line and is shown as the lower passage on the lubrication diagram. This line serves both the governor pump and the tappet and rocker arm assemblies. The tappets and rocker arms will be considered first.

The oil is discharged to an annulus surrounding the governor drive shaft bushing. It lubricates this bushing, and is led from the annulus through a drilled passage to connect with the channel machined into the shoulder on the rear face of the crankcase front section. This channel is sealed by the rubber oil seal ring of T-cross-section between the crankcase front section and the crankcase front main section. From it, drilled passages lead to the eight tappets which are located above the horizontal center line of the engine. Mating holes in the tappets and guides lead the oil to the inside of the tappets. From here it is forced through the hollow push rods to the rocker arms. The rocker arms are also drilled, and the oil is forced to the rocker arm bearings under pressure. Oil escaping from the bearings lubricates the valve stems. Return oil flows down the space between the push rods and push rod housings, through holes in the tappet guides, and then back into the front section, lubricating the tappet roller and cam surface.

Tappets, rocker arm bearings, and valves below the horizontal center line are lubricated by crankcase oil seeping through the clearance between each valve tappet and its guide, after which it passes through the inside of the push rod housing and fills the rocker box. The desired quantity of gravity fed oil for this purpose is obtained by controlling the valve tappet diametric clearance in their guides.

When a governor is used, the governor takes oil from the low pressure line and increases its



Oil Pump Assembly

pressure to that required for propeller operation. This high pressure oil is returned to the propeller shaft through drilled passages in the front section and stationary reduction gear support to the passage between the two forward sets of rings in the thrust bearing spacer.

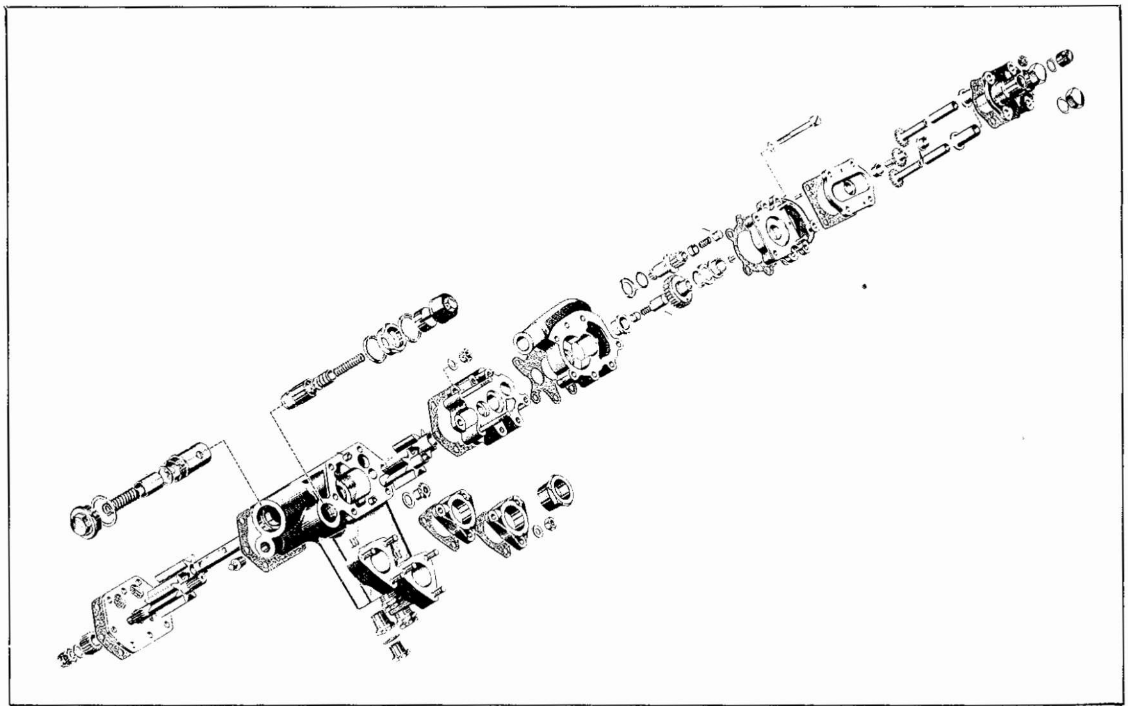
From the forward space in the thrust bearing spacer, the high pressure oil is led through a hole in the propeller shaft to the annulus between the propeller shaft and the propeller shaft sleeve. From here it is taken through the adapter to the hydromatic propeller. This passage is sealed at the adapter if an electric propeller is used.

All return oil drains to the sump. The power section oil drains from the bottom of the crankcase main section through two short tubes into the front section, where it joins the front section drainage, and passes into the sump through the front section connection. The power section oil also drains from the rear of the crankcase main section into a cored passage in the supercharger front section, joining the drain oil from the accessory drive section. Oil from the accessory drive section or supercharger rear housing, drains through cored passages in the supercharger front and rear housings and through the left hole in the left arm of the sump. Front section flow and rear section flow may be diverted for test purposes to obtain an accurate measurement of oil flow from the power section alone.

Breathing takes place through the sump connections to the right arm of the sump. This arm connects through a boss on the supercharger front section to a large passage leading to the breather vent outlet. Some engines use a crankshaft breather in place of this external breather. Of the six cored holes in the supercharger front section breather passage, all are plugged but one which is equipped with a breather relief valve. Its purpose is to provide a more direct outlet for any gases that create excessive pressure in the power section.

Oil is withdrawn from the sump through the right of the two holes in the left arm of the sump. External oil scavenge lines are supplied with some engines. The external oil line is connected to an adapter at the front of the sump oil strainer and is routed close to the engine crankcase to a vertical or horizontal scavenge oil inlet at the oil pump. The tube is clamped to the engine at several locations to prevent vibration.

CARBURETION The series C9-GC engines are equipped with either a Holley, Bendix-Stromberg, or Chandler Evans carburetor.



Oil Pump Assembly with Provision for External Oil Scavenge Line

The Holley carburetor has a single air passage controlled by a variable venturi. Fuel is admitted to a supply chamber by a diaphragm mechanism. A controlled pressure differential produced by the variable venturi causes fuel to flow from the supply chamber to the metering nozzle located in the venturi throat. The fuel discharge nozzle and venturi throttles are arranged in such a manner that the carburetor is inherently free of ordinary icing troubles. Also the type of fuel metering system and throttle used in this carburetor provide partial compensation for changes in altitude. More exact altitude adjustment and increased economy under favorable operating conditions are obtained by means of a manual control which is provided for leaning out the fuel air ratio.

The Holley carburetor is also provided with a fuel cut-off device which is brought into action by moving the mixture control to the full lean position.

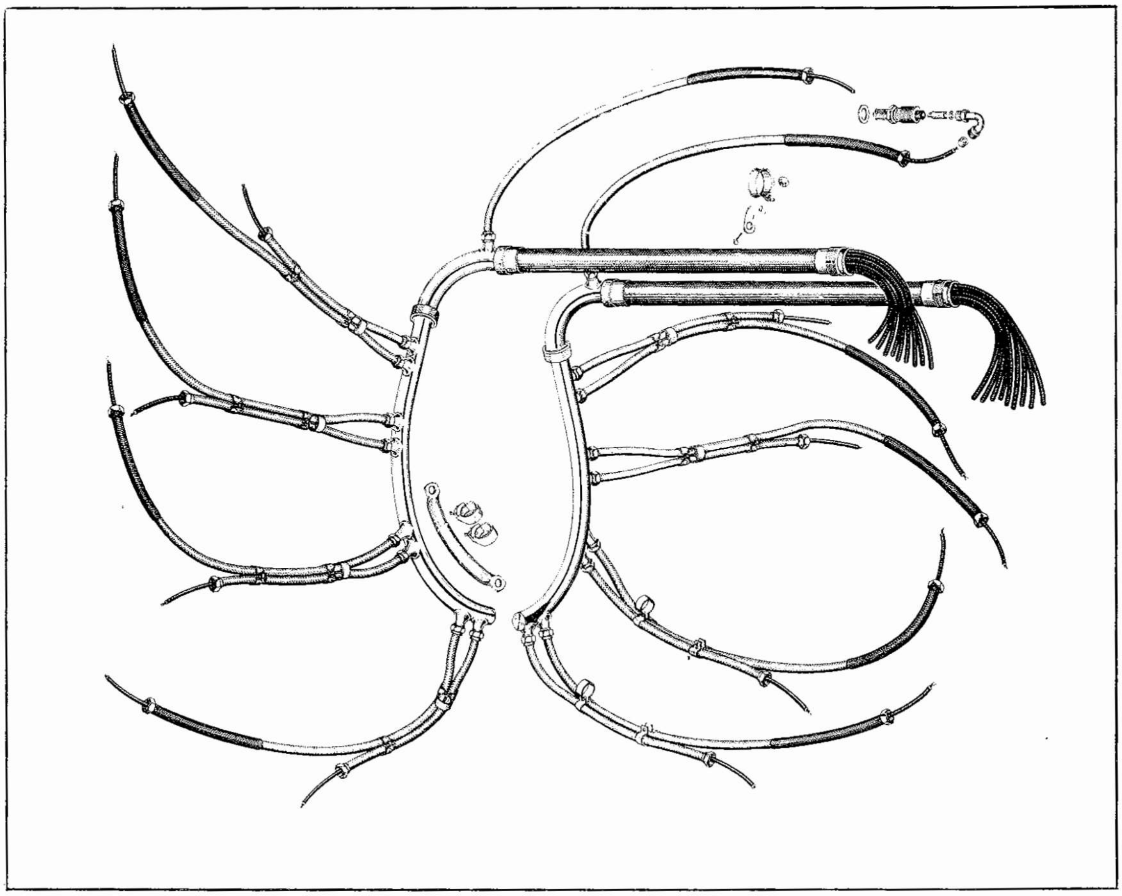
The accelerating pump on the Holley carburetor functions only when the engine is running. Consequently, opening or closing the throttle prior to starting will not flood or prime the engine. A charge of fuel is retained by the accelerating pump for approximately two hours after the engine is stopped if the mixture control is left in the cut-off position. Movement of the mixture control to the full rich position when cranking the engine will permit the use of this charge to assist in re-starting.

The Bendix-Stromberg injection carburetor employs the method of metering the fuel through fixed orifices according to the venturi suction, combined with the function of atomizing the fuel spray under positive pump pressure. This carburetor is inherently ice-free as the fuel is injected below the throttle venturis.

The fuel enters the metering system at a pressure above that in the supply tank. The fuel is delivered by the engine fuel pump into the regulator and control units where it is metered according to the mass air flow rate, as registered by the venturi tube and aneroid system of the throttle unit. The fuel is then forced to the discharge nozzle, located to spray the charge evenly across the supercharger entrance.

The control unit contains a cruise metering jet which can be modified to rich cruise and lean cruise by the manual control, also a take-off metering jet which is brought in gradually according to engine horsepower increase, as measured by mass air-flow rate.

Both cruising and full power mixture ratios are kept constant under temperature and altitude



Ignition Harness

change by the automatic mixture control unit.

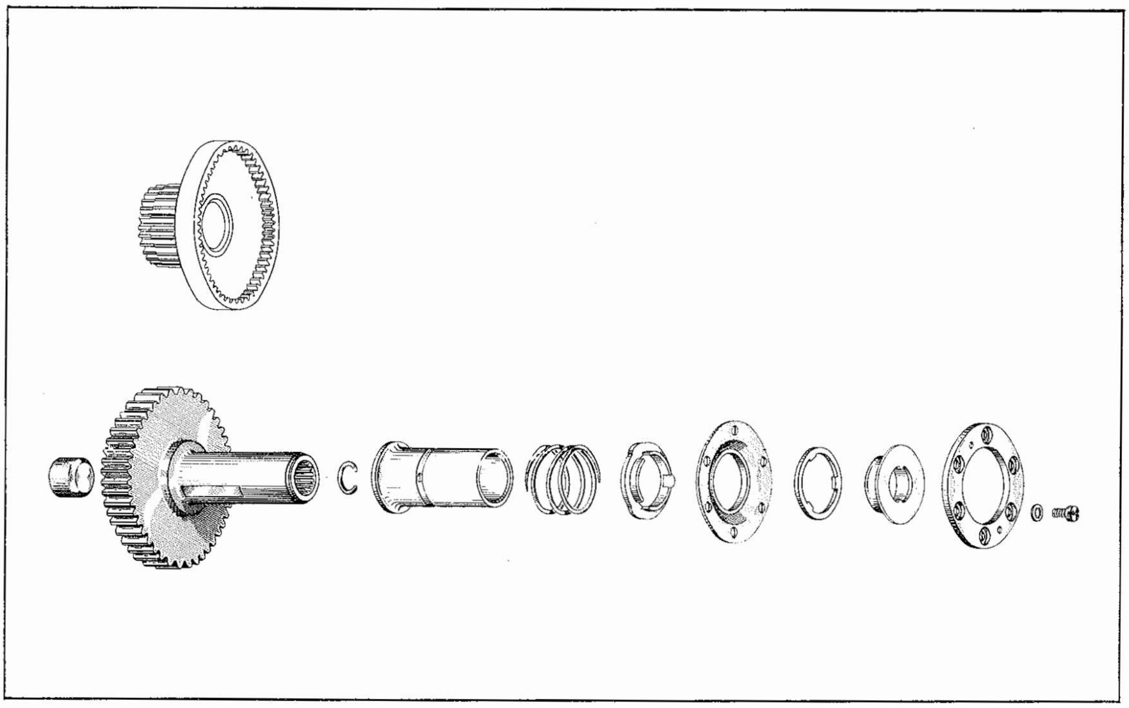
The Bendix-Stromberg Injection carburetor is also provided with a fuel cut-off device which is brought into action by moving the mixture control to the "Idle Cut-Off" position.

The Chandler Evans carburetor is similar to the Holley in construction and the Holley operating instructions apply to it without change.

IGNITION Ignition is furnished by two Scintilla magnetos mounted on the rear cover. The right hand magneto fires the front spark plugs, and the left hand magneto fires the rear spark plugs. Both magnetos rotate at $1\frac{1}{8}$ crankshaft speed in the direction of crankshaft rotation. The spark advance to be used is stamped on the engine data plate. The magnetos may be equipped with blast covers and tubes to aid in directing cooling air to the magneto housing. Magnetos are compensated for equal spark advance on all cylinders.

The wire, enclosed in bronze or stainless steel cables, is rubber insulated and coated with a protective compound to prevent wear and deterioration. The manifold consists of two semicircular rings of stainless steel or cadmium plated brass tubing. These tubes are attached to the front section cap screws and carry the ignition wires for their respective sides of the engine. Clips on the push rod housings and cylinder head deflectors prevent the ignition leads from rubbing against the engine. Terminal assemblies are provided at the end of the front and rear of the ignition leads, forming a very compact and efficient connection at the spark plug.

All parts of the ignition system are shielded against radio interference. The shielding is constructed so that any part, if damaged, may be readily replaced without discarding the entire shielding structure. Any defective ignition wire may likewise be replaced without disturbing other wires.



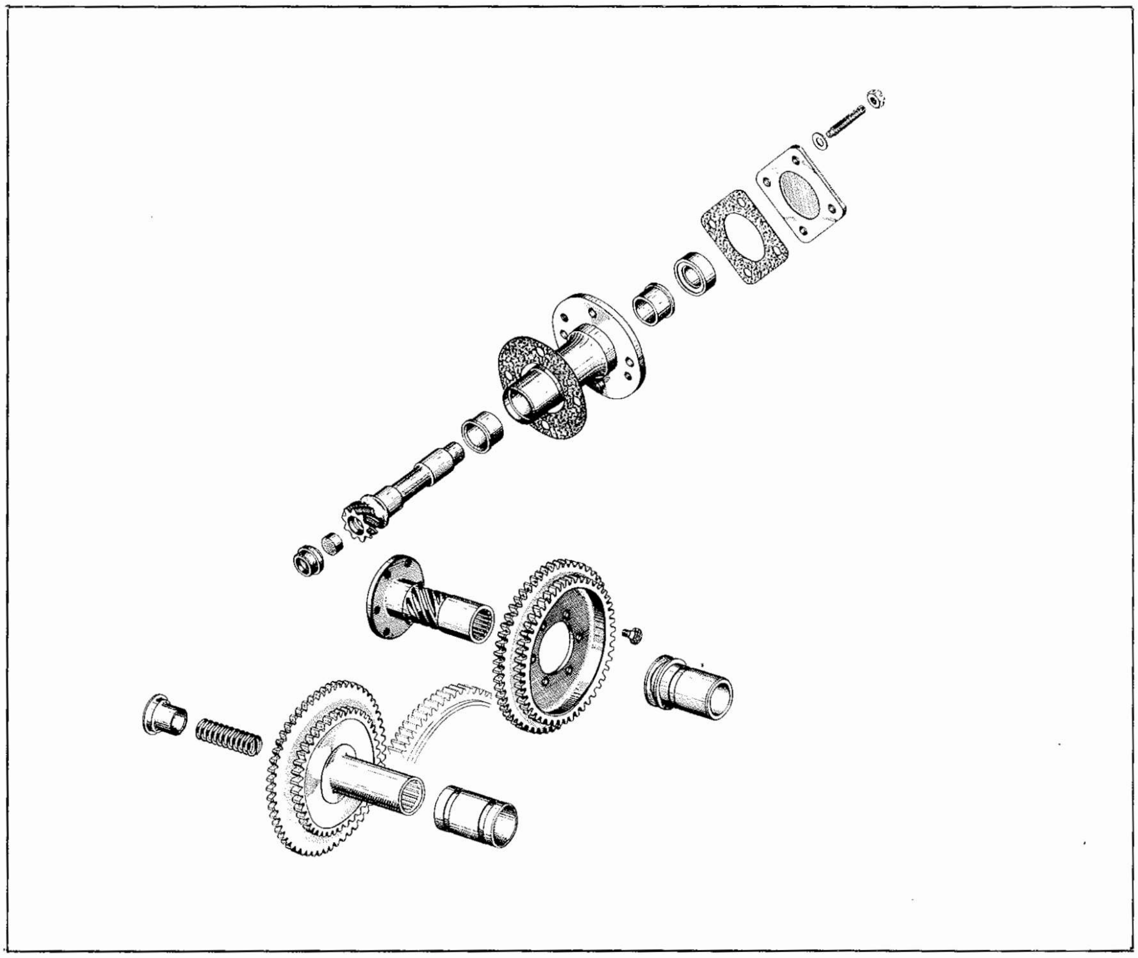
Generator Drive

GENERATOR DRIVE The rear cover of the C9-GC engine is provided with a pad suitable for attachment of a generator with a six bolt round mounting flange. The drive shaft rotates at 1.5 times crankshaft speed and in the same direction as the crankshaft. It is machined to receive a generator shaft with sixteen involute splines.

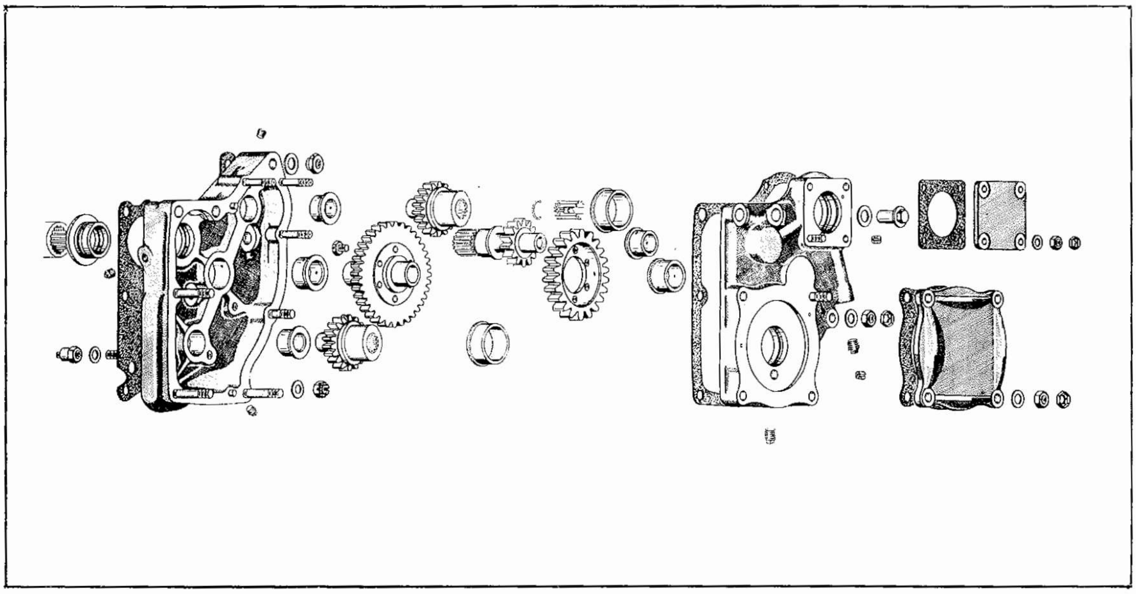
TACHOMETER DRIVES Provision is made at the rear end of the oil pump for two tachometer drives, one electrical and one mechanical. The tachometer drives are effected by a small drive shaft which is splined at one end to mate with similar splines in the pressure oil pump drive shaft. Oil leakage is prevented by the use of spring loaded plungers and neoprene ring oil seals. The extended type is the mechanical tachometer and the flange type is the electrical. Both the tachometer drives have the same speed ratio and rotate in a clockwise direction.

Oil pumps incorporating an external oil scavenge line are equipped with only the electrical tachometer drive. However, an alternate arrangement is provided whereby two mechanical tachometer drives replace the electrical drive. An adapter, a pinion, two mechanical tachometer drive shafts, and a dual tachometer drive housing are assembled on the electric tachometer drive pad to form the alternate arrangement. The drive is effected by the pinion which has a square tongue drive in the electric tachometer drive gear and which meshes with the gears at the end of each mechanical tachometer drive shaft.

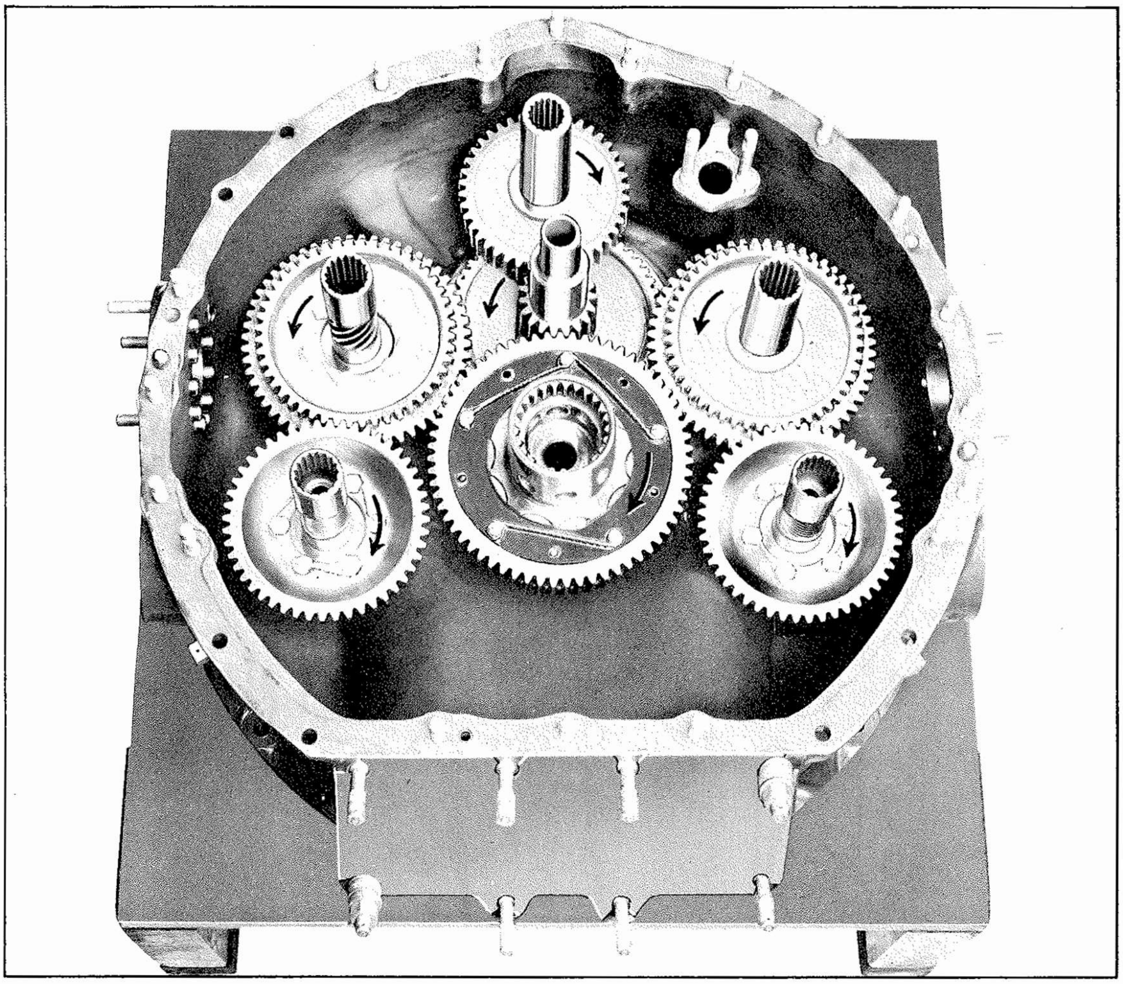
DUAL ACCESSORY DRIVE Provision for optional accessory drives is made possible by the use of a spur gear box attached to the supercharger rear housing cover at the spare drive mounting pad. The gear box body is composed of a magnesium alloy casting, studded for the attachment of an aluminum alloy cover plate. The bushings which support the gears are located in the cover plate and in the body of the gear box. The main drive gear is machined integral with the shaft that extends through the upper left-hand corner of the housing wall to mate with the spare drive gear shaft in the supercharger rear housing cover. This main drive gear meshes with an intermediate gear near the center of the housing to make up the primary or first gear train of the unit. The secondary train of gears, identified by their smaller teeth, consists of a secondary driving gear which is bolted to the primary intermediate gear, and two accessory



Oil Pump and Fuel Pump Drives



Dual Accessory Drive Mechanism



Relative Positions of Accessory Drives Showing Directions of Rotation

drive gears. To change the speed ratio of the accessory drives to the crankshaft, it is only necessary to replace the two gears in the primary gear train. All the gears are machined from alloyed steel forgings. The lower accessory drive is supported by two oilite bushings while the upper drive is supported by an oilite bushing in the cover and a bronze bushing in the housing. All the other drives in the unit are supported by bronze bushings. Both the housing and cover of the unit are drilled for oil passages. Provisions are made for the conversion of the splined drives to the tongue type drive by the addition of steel couplings. An adapter equipped with drilled oil passages may be installed on the lower drive pad if it is desired to mount an accessory with a smaller mounting pad.

FUEL PUMP DRIVE Provision is made for mounting a fuel pump on the right side of the supercharger rear housing. The mounting pad is circular and is fitted with twelve tapped holes equally spaced. The round pad on the shaft support is drilled with four stud holes. With this arrangement, the fuel pump may be installed in any one of twelve positions.

CHAPTER II

PREPARATION FOR STORAGE OR SERVICE

GENERAL Slushing of all engines which are stored or which remain idle is recommended in order to prevent corrosion of the metal parts of the engine. Slushing is accomplished by coating the internal metal parts of the engine with a preservative compound. The recommendations contained herein apply to slushing of engines which are to be stored in an airplane or on a stand, as well as engines which are to be removed from the airplane or stand for storage or shipment. These recommendations also apply to the reslushing of engines which are received from this factory if the engines do not pass inspection as specified in this instruction.

It is recommended that all engines which are to be placed in storage, disassembled, or are to remain idle for a period exceeding 48 hours be run out on unleaded 65 octane fuel conforming to W.A.C. Specification No. 5800. Following the run-out, the engine should be slushed. If the engine is to be disassembled and the parts cleaned and slushed within the specified 48 hours, it is unnecessary to run out on unleaded fuel. If, due to internal failure, the engine can not be turned over either by an air driver or by hand, and it can not be disassembled within 48 hours, the engine should be slushed in any practical manner so as to keep the salvageable engine parts in as good condition as possible.

UNLEADED FUEL RUN-OUT Engines should be run out on unleaded fuel in order to prevent corrosion caused by tetraethyl lead, a constituent of high octane fuel. Operate the engine at an idling speed and at low power, not exceeding 50 per cent of rated power, for a minimum of fifteen minutes. Just prior to stopping, increase the speed to 1000-1200 r.p.m. and hold for one-half minute to obtain optimum scavenging of oil from the engine. At the end of the run-out, stop the engine by closing the valve on the fuel line, to empty the carburetor of all gasoline. If the engine is run out on unleaded fuel prior to slushing, remove the spark plugs to permit combustion vapors to escape from the cylinders before condensation takes place. Install vented dummy plugs in all spark plug holes.

EQUIPMENT The following equipment is recommended for use in slushing engines: Spray gun, Tool No. 84263, is recommended for use in overhaul shops where the volume of work is large. Equipment provided under this tool number includes the gun, pressure tank, pressure regulator, and all hoses and connections. Spray gun, Tool No. 83905, is recommended for use in overhaul shops where the volume of work is not particularly large. A small tank which contains the slushing compound is provided integrally with this spray gun. An air driver, Tool No. 83903, which is installed on the engine starter pad and which is used to turn the engine crankshaft during some of the slushing operations, may be procured if desired. This driver is recommended for use in overhaul shops where the volume of work is large.

Rocker box covers, Part No. 800922, modified by cutting away the front half, are used when slushing valve stems and valve guides.

A list of the parts and part numbers used in preparing the C9-GC engine for storage follows:

Pliofilm shipping envelope, Part No. 116603.
  Note: Pliofilm is sensitive to light and will deteriorate if exposed for any appreciable time.
Pliofilm carburetor envelope, Part No. 116608
Cylinder dehydrator plugs—(short type)—Part No. 116538N1
Spark Plug Terminal Protectors and cable attachment, Part No. 116539N1
Sump dehydrator plug, Part No. 117849N1

Humidity indicator card, Part No. 116601
Dehydrator agent Protek-Sorb (Silica-Gel)—
½ lb. package, Part No. 116600
¼ lb. package, Part No. 116618
Heating iron for sealing Pliofilm bags, Part No. 802924
Engine opening sealing envelope, Part No. 116625
Engine opening sealing envelope, supercharger drain valve, Part No. 116623
Exhaust pipe flange gasket (shipping or storage only), Part No. 117948
Gasket and Protek-Sorb Assembly, Part No. 418108
Engine Slushing Compound, AMS Specification No. 3072
Carburetor Slushing Compound, AMS Specification No. 3070

The ¼ and ½ lb. dehydrator bags contain activated silica-gel crystals which absorb moisture. The degree of activity of the crystals may be determined only by referring to the relative humidity chart. The Protek-Sorb bags must be replaced with freshly activated bags when the humidity chart indicates an unsafe humidity condition. The crystals in the bag are not color treated.

The cylinder dehydrator plugs which are used in the spark plug holes consist of transparent containers filled with silica-gel crystals and threaded at the end. These crystals are cobalt blue when new and change in color, as they absorb moisture, from cobalt blue to light blue, to dark pink, to light pink.

The humidity indicator chart is a 5 by 8 inch card consisting of a color and relative humidity chart on each side of a transparent section filled with silica-gel crystals. The crystals are cobalt blue when freshly activated and change in color as they absorb moisture. It is the purpose of this card to indicate the relative humidity within the engine envelope. As the crystals match with the color chart, the humidity within the engine envelope may be determined as safe or unsafe. When the crystals can be matched with the dark pink or light pink sections on the color chart, or when the humidity indicator shows a relative humidity greater than 20 per cent, the dehydrating agents must be changed as described in these instructions.

SLUSHING PROCEDURE If the engine is to be removed from the airplane or test stand for the inoperative period, remove the engine at this time and mount on a revolving cradle type engine floor stand before performing the following slushing operations. If the engine is to remain in the airplane or on a test stand for the inoperative period, remove the propeller and perform the following slushing operations immediately:

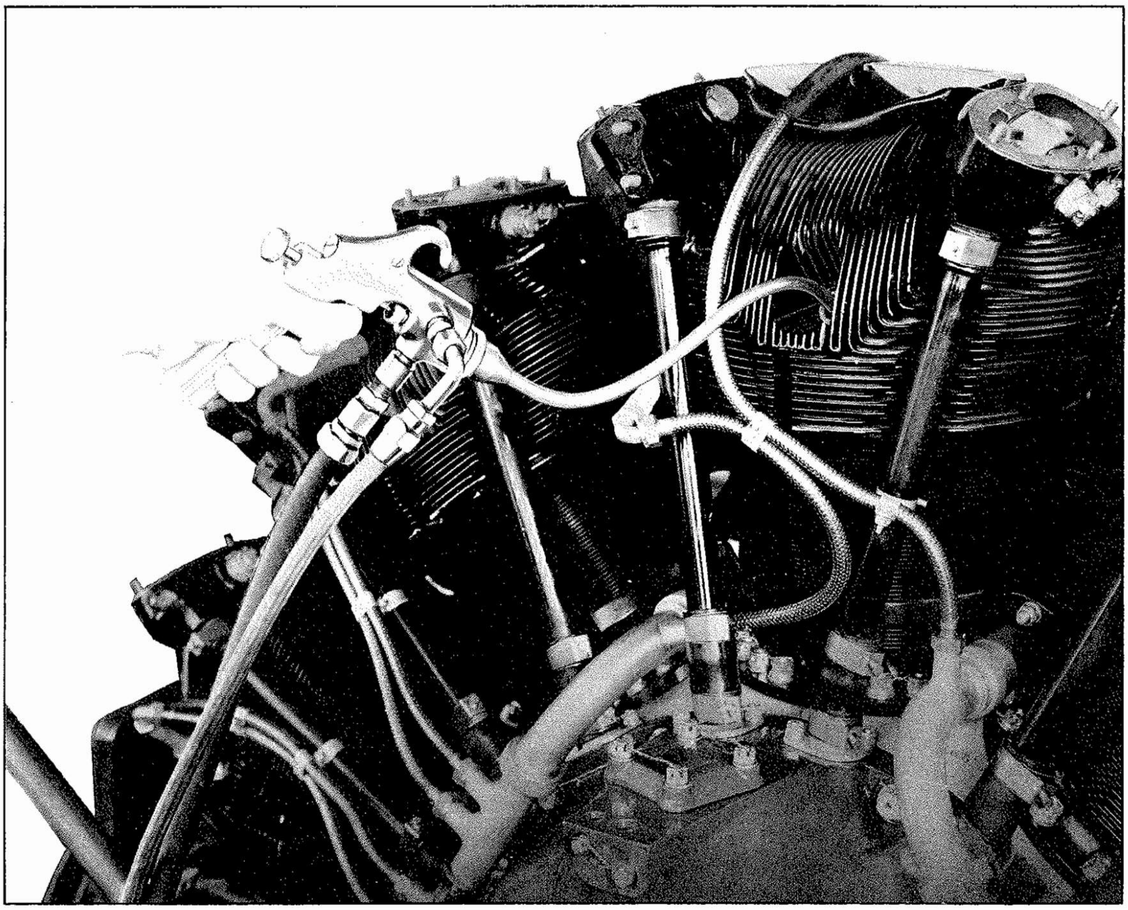
Remove both the screened plug and the magnetic drain plug from the sump and drain the oil from the sump. Wash these plugs thoroughly, using a mixture of 50 per cent wash gasoline and 50 per cent benzol, or an equivalent cleaner. Slush the screened plug in AMS Specification No. 3072 compound and reinstall in the sump. Replace the magnetic drain plug with the dehydrator sump plug.

Remove the oil filter, wash in the gasoline-benzol mixture or equivalent, and slush in the compound. Remove from the supercharger rear housing, the oil tank vent tubes or plugs, located directly above the gun synchronizer mounting pads. Using the spray gun and the slushing compound, spray through each opening for 5 to 10 seconds in order to coat all internal parts of the supercharger rear housing thoroughly with the compound. While spraying, turn the crankshaft slowly in order to turn the accessory driving gears. Insert the nozzle of the spray gun in the oil filter hole and slush this cavity completely. Replace the oil filter and lockwire securely. Replace the oil tank vent tubes or plugs.

If the accessories on the rear cover have been removed for separate packing, spray the accessory drive recesses in the rear cover with the compound. Seal the openings by covering them with oil and moisture resistant gaskets and install cover plates over the accessory drive mounting pads.

Slush the fuel pump in the following manner: Attach a funnel by means of a rubber hose of approximately ¾ inch inside diameter to the inlet to the fuel pump. Fill the funnel with a pint of slushing compound. Slush the fuel pump with the compound, turning the crankshaft through several revolutions in the normal direction of rotation. Allow the compound to drain at the fuel pump outlet.

Slush the interior of the crankcase front section in the following manner: Remove the exhaust push rod housing and push rod from No. 1 cylinder. In order to remove the push rod after the push rod housing has been loosened, it will be necessary to remove the rocker box cover, to loosen the exhaust rocker arm valve clearance adjusting screw all the way out to its stop,



Slushing the Combustion Chamber

and to slightly compress the valve spring. Refer to the removal instructions in Chapter VII. This will force the rocker arm down at the valve end, allowing the push rod lower end to be removed from the slotted tappet guide. Remove the push rod and housing together. Remove the corresponding tappet guide and tappet assembly from the crankcase. If the engine is installed on a revolving cradle type disassembly stand, turn the engine on the mounting stand until the open tappet hole is pointed directly downward, and allow any oil remaining in the crankcase front section to drain out the tappet hole. Then turn the engine on the mounting stand until the propeller shaft is pointed directly downward, and pour slushing compound into the open tappet hole until the crankcase front section is filled to the level of the hole. Turn the engine again until the open tappet hole is pointing downward, and allow all the slushing compound to drain out of the front section. Return the engine to the horizontal position and reinstall the parts which were removed. If the engine remains installed in an airplane or on a test stand, slush the interior of the crankcase front section by spraying, using the spray gun and the slushing compound. Insert the nozzle of the spray gun in the open tappet hole and spray for at least thirty seconds. Turn the crankshaft while spraying to insure that all parts are thoroughly coated with compound. After spraying, reinstall the parts which were removed.

Slush valve stems and valve guides in the following manner: Remove all the remaining rocker box covers. Using a wash gasoline spray, wash the rocker box interior and the rocker arm and valve spring assembly in all rocker boxes. After washing, dry the rocker box interiors using an air blast. If the engine is installed on a revolving cradle type disassembly stand, turn the mounting cradle until the engine is in the front-end-up position. Install modified rocker box covers on all rocker boxes, and fill the rocker boxes with compound after heating the com-

pound to approximately 190°F. Slush the valve stems and valve guides by turning the crankshaft to work the compound between the valve stems and valve guides. The crankshaft should be turned through at least 120 revolutions in order to insure that the valve stems and valve guides are adequately slushed. Install rocker box covers after slushing.

If the engine remains in the airplane or on the test stand, spray the interior of the rocker boxes using the spray gun, while actuating the valve by turning the crankshaft.

Spray into the induction chamber in the supercharger rear housing using the slushing compound while turning the engine over. Install the gasket and dehydrator bag assembly and seal the opening with the metal plate cover. Secure the cover with nuts on the carburetor adapter attachment studs.

Remove the plugs from the spark plug holes and slush the interior of the cylinders using the spray gun and the slushing compound, inserting the nozzle of the spray gun through the spark plug insert hole. Turn the crankshaft so that the piston in the cylinder being sprayed is at the bottom of its stroke with the intake valve open. Spray for ten or fifteen seconds to insure that all parts of the cylinder interior and the interior of the intake port are coated with compound. Care must be taken not to damage the threads in the spark plug insert when inserting and removing the nozzle of the spray gun. Repeat this operation in the cylinder with the piston at the bottom of its stroke and the exhaust valve open, and spray the interior of the exhaust port. Follow this procedure for all cylinders. After spraying, install dehydrator plugs in the spark plug insert holes to prevent the entrance of dirt or foreign material, install the spark plug terminal protector and cable attachment over the spark plug contacts. Secure the spark plug cables to prevent chafing.

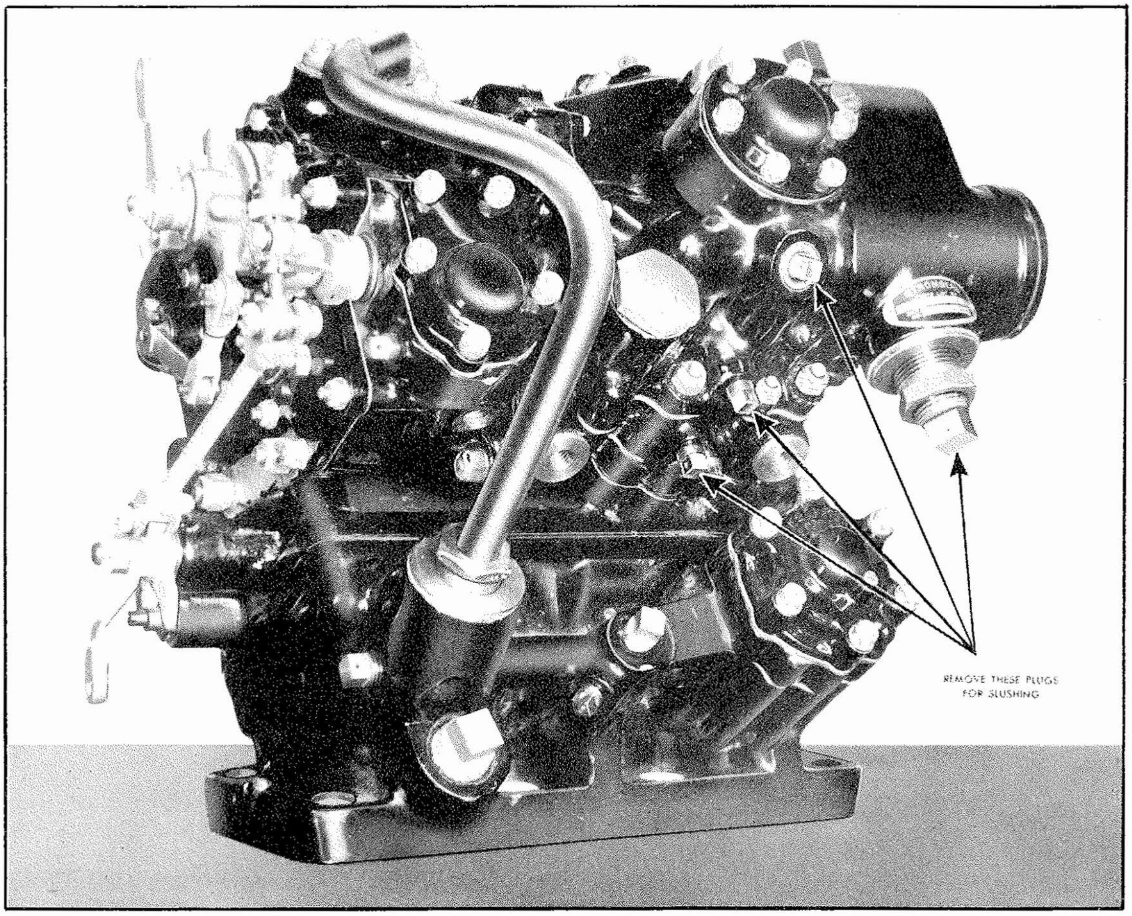
Wash the carburetor with dry cleaner naphtha to remove carbon and dirt. Remove all fuel drain plugs from the carburetor allowing the contents to drain completely. Refer to the carburetor manufacturer's instructions for the location of these plugs. Plug the fuel inlet. Open the throttle lever to wide open position and the mixture control to the full rich position. Close the throttle on Holley carburetors. With the drain holes up, fill the fuel passages with the slushing oil AMS Specification No. 3070. Allow the carburetor to stand for ten minutes; invert, and drain for ten minutes. Replace all drain plugs and lock wire. Spray all the exterior surfaces with the carburetor slushing oil.

Immediately after completion of the above slushing process, tie a ½ lb. bag of dehydrating agent to the carburetor and seal the carburetor in a transparent moisture resistant envelope.

After slushing the interior of the engine, the exterior must be washed. Tie protective bags over the magnetos prior to washing the engine. Fasten oil and moisture resistant gaskets and cover plates on the exhaust port flanges. Wash the exterior of the engine thoroughly using a wash gasoline spray. Dry the engine thoroughly with an air blast after washing. Coat the exterior of the propeller shaft with the slushing compound and install a protecting cap on the threaded end of the propeller shaft.

PACKING PROCEDURE Prepare a pliofilm envelope for use. The envelope is fitted with four sets of oil and moisture resistant gaskets, which are attached to both sides of the Pliofilm, and so located as to align with the bolt holes in the engine mounting plate. One set of the gaskets is colored. Sufficient material is left below these gaskets to permit the envelope to fit loosely around the rear section of the engine. Using a chain hoist, remove the engine from the stand. Draw the envelope up over the rear end of the engine with the colored gasket located on the mounting boss just below number one cylinder. Fasten the envelope temporarily to the engine by means of spring clips to any protruding part of the engine. It is advisable to reinforce the gaskets on the Pliofilm envelope at the mounting bolts with heavy cardboard or rubber, to assist in preventing possible damage to the envelope.

Lift the mounting plate into position under the engine, align the engine mounting bosses, the holes in the gaskets in the Pliofilm envelope, and the holes in the engine mounting plates. Insert the mounting bolts, piercing the Pliofilm envelope through the gasket holes if the envelope is new, and fasten the mounting plate in the usual manner. Inspect carefully to see that the envelope has not been ruptured and that the mounting plate has been securely anchored in position. Lower the engine, mounting plate, and engine envelope into the packing box in front-end-up position. When the engine is to be stored on a test or floor stand, or in an airplane, the mounting plate will not be attached to the engine. Secure the engine to the box, stand, or



Slushing Plugs — Bendix-Stromberg Carburetor

airplane. If the engine is to be stored in an airplane, no Pliofilm envelope is used.

Seal the crankcase breather, the supercharger drain valve, and the impeller oil seal vent with Pliofilm or rubber caps.

DISTRIBUTION OF DEHYDRATING AGENT Suspend either two ½ lb. or four ¼ lb. bags of dehydrating agent near or about each cylinder. These bags may be attached to the cylinders at any convenient locations.

Secure a humidity indicator chart to the engine on number one cylinder so that it will face out from the engine, and be located opposite the inspection port in the shipping box. Place the card so that it may be readily observed through the port from the outside of the box, when the port cover plate is removed. In the case of an engine stored in an airplane, this procedure is not adhered to.

If a propeller breather is used, a ¼ pound bag of dehydrating agent shall be placed in the propeller shaft against the breather screen. The protector cap shall be screwed down tightly.

SEALING THE ENVELOPE Bring the open edges of the envelope together over the top of the engine, and, using the sealing iron at 325 to 350° F., seal the two edges of the envelope over a ½ inch wide area about ¼ inch from the edge of the cut.

A board covered with cardboard may be used to back up the Pliofilm when the iron is run over it. A well vulcanized seam will be transparent throughout the length of the seam, but a poor seam, in which the iron was not at the right temperature or the surfaces were not pressed together, will be cloudy or filmy. A poor seam should be repaired by repeating the operation more slowly until the seam is transparent. Care must be taken not to damage the Pliofilm with too hot an iron.

There will be sufficient material in the upper part of the envelope so that the sealed edge can be cut off when the engine is removed. This excess material permits the envelope to be used five or six times.

After the sealing is finished, fold the excess material around the engine and secure it with tape so that there shall not be more than one thickness of envelope film between the humidity indicator and the inspection port in the side of the case.

CAUTION: **Extreme care must be exercised during these operations to prevent breakage of the envelope. Inspect carefully to see that no rupture has occurred. The repair of a rupture is described in the section on Maintenance.**

INSPECTION Engines in storage must be inspected once a month to determine the relative humidity inside the engine envelope. If the activated crystals in the humidity indicator, located within the Pliofilm envelope and opposite the port hole on the packing case, are blue or light blue, the humidity is within the limits permitted.

If the activated crystals are pink or light pink, it indicates that the humidity is greater than 20 per cent. The box cover must then be removed, the Pliofilm bag must be slit, and all the bags of dehydrating agent must be replaced. It should be noted that the protective plugs in the rear spark plug holes may become loaded with slushing oil. This is not harmful and the plug continues to work effectively. Since it is sometimes difficult to determine the color of the plug when full of oil, the top plugs should be considered the indicator. The Pliofilm bag may then be resealed according to instructions previously described.

MAINTENANCE Whenever a failure occurs that will permit the entrance of moisture into the Pliofilm envelope, the envelope may be resealed with the iron by following the procedure previously described or by resealing with any durable sealing tape. Careful inspection should be made of the humidity indicator following the repair of a failure, to ascertain whether or not the moisture within the envelope has increased to the danger point.

UNPACKING Wright engines are shipped from the factory in sealed packing boxes. The following procedure should be adhered to in unpacking the engine as received from the factory or as prepared for storage in the field in accordance with the foregoing recommendations. Break the seals found on the cover hold-down bolts at the sides of the box. Remove the nuts from the bolts found directly below the lifting hooks and lift off the cover with the hooks provided. Slit the Pliofilm around the top seam, just over the propeller shaft, to allow the removal of the thread protecting cap and insertion of the hoisting eye. Remove the nuts to free the mounting plate from the box cradle. Then remove the engine and plate from the box with a chain hoist.

If it is desired to store the engine without the box as on an engine stand, the Pliofilm may be left on the engine. The slit above the propeller shaft, however, must be closed as indicated in the previous instructions.

If the engine is to be installed immediately, the slit along the top seam should be continued across the entire envelope and the envelope should be rolled down over itself to the adapter plate. The plate may then be removed taking care not to damage the envelope below it. After this is done, the envelope should be removed.

After removing the envelope, the bags of dehydrating agent should be removed from their positions around the engine and in the carburetor adapter. The sump dehydrator plug should be removed and the remaining slushing oil allowed to drain out. Replace the magnetic plug. The dehydrating bag should be removed from the carburetor, and then the carburetor should be drained and replaced on the engine. After this is done, the engine may be set up for operation. No extra change of oil is necessary since the slushing compound does not oxidize to a gummy residue. The dehydrator plugs in the spark plug holes should be removed and replaced with spark plugs just before the engine is to be run.

CHAPTER III

INSTALLATION IN THE AIRPLANE

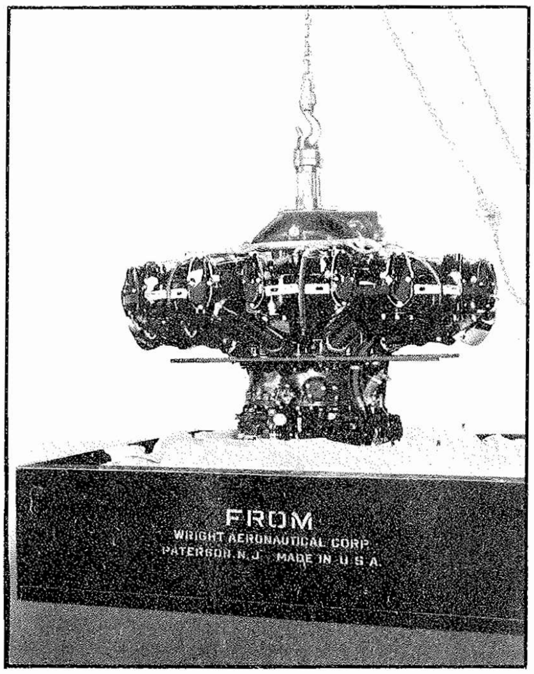
DETAILED instructions on the installation of a Cyclone engine may be obtained upon request from the Wright Aeronautical Corporation, Service Division. Copies of installation drawings may also be obtained upon request. These drawings consist of a basic drawing for the engine in question and supplementary drawings covering various individual requirements.

UNPACKING AND PREPARATION FOR SERVICE Refer to the directions in the preceding chapter when unpacking and preparing an engine for service. If it is intended to lift the engine to a horizontal position with the engine sling, do not remove the bolts holding the mounting plate to the engine until the engine has been raised to the desired position.

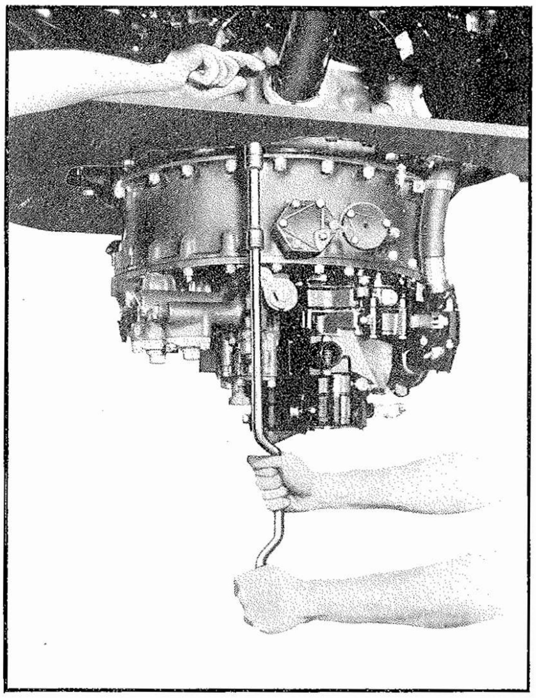
Improper use of the engine hoisting equipment may result in serious damage to the engine. The hoisting equipment supplied with the engine must not be used to lift an airplane or to lift an engine which is attached to its mount. The equipment must not be attached to any part of the engine except where it was designed to be attached.

The hoist sling is attached to the cowl mounting studs on the front and rear of the intake rocker boxes of No. 1 and No. 9 cylinders.

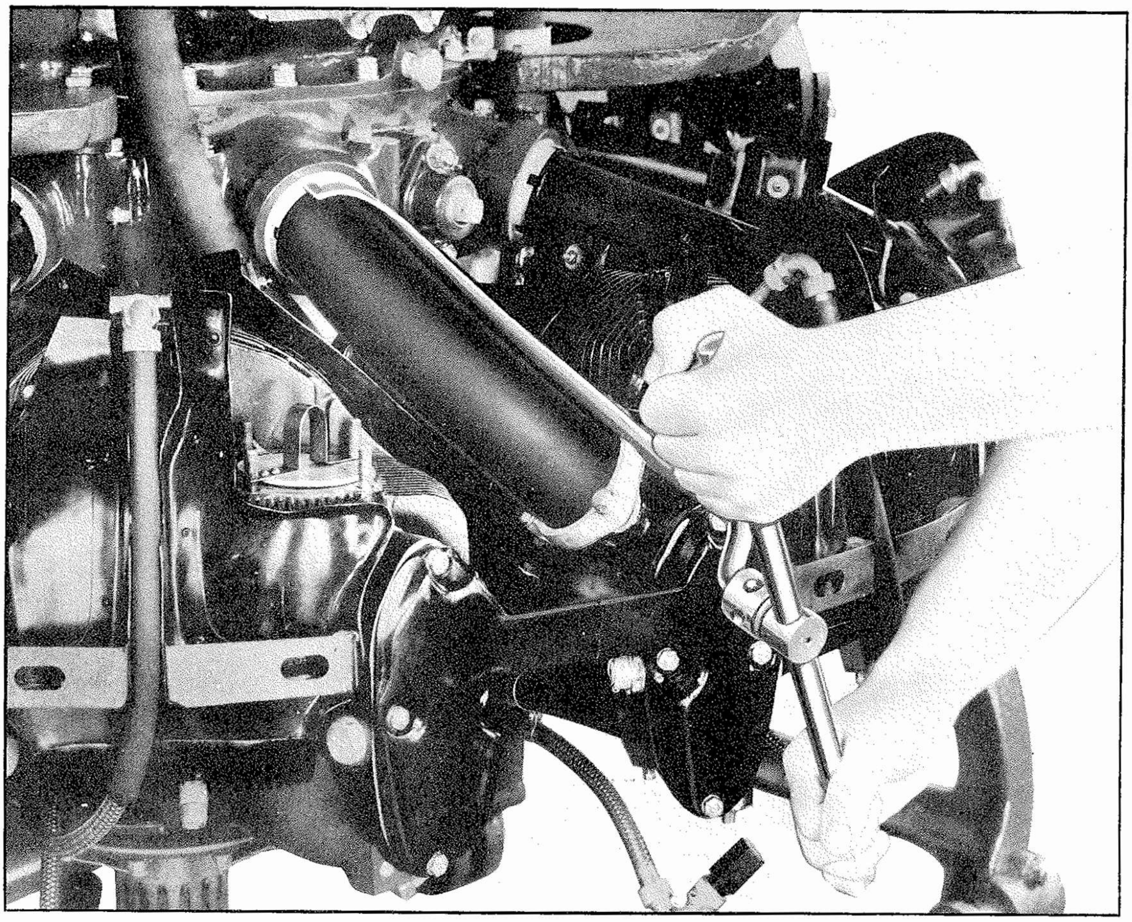
WARNING: **Under any circumstances, do not remove the engine from the mounting plate while the plate is attached to the base of the shipping box.**



Removing Engine from Shipping Box Showing Hoist Arrangement



Removing Mounting Plate



Loosening Intake Pipe Packing Nut

METHOD OF MOUNTING ENGINE An engine mounting boss is located on each of the nine intake ports on the supercharger front housing. These holes mate with corresponding holes on the engine mount.

INTAKE PIPES After installation, the lower intake pipes should be removed and inspected for any collection of oil or slushing compound. If any excess oil or compound is found, the adjacent intake pipes on each side should be removed and examined, continuing toward the top cylinders until no oil or compound is found.

When removing the intake pipes, the packing gland nut at the crankcase should be loosened prior to loosening the intake pipe at the cylinder. These operations should be performed in the reverse order when reinstalling the intake pipes. These precautions will prevent any damage to the intake pipes, attaching flanges, packing, and gaskets.

Arrangement of Hoisting Sling

ACCESSORY DRIVES The Wright Aeronautical Corporation will assume no responsibility for the failure of an engine directly traceable to the failure of an accessory. In order to avoid uneven stress and consequent failure of the accessory attaching flange, care should be exercised to insure that all nuts are drawn up evenly and uniformly when an accessory is installed.

The direction of rotation of the various accessory drives and the ratio of the speed of the drive to the crankshaft speed are given in the following table. An exception is made in the case of gun synchronizer drives, which operate at propeller shaft speed as noted.

	Direction of Rotation	Ratio of Drive to Crankshaft Speed
Starter	Clockwise	1:1
Generator	Clockwise	1.5:1
Magneto (Right)	Clockwise	1.125:1
Magneto (Left)	Clockwise	1.125:1
Fuel Pump	Anti-Clockwise	1:1
Dual Accessory Drive		
(Upper)	Anti-Clockwise	1.5:1*
(Lower)	Anti-Clockwise	1.5:1*
Propeller Governor (Mounted on Crankcase Front Section)	Clockwise	1:1
Gun Synchronizer (Right)	Anti-Clockwise	Propeller shaft speed
Gun Synchronizer (Left)	Clockwise	Propeller shaft speed
Tachometer Drives (Mounted on rear of Oil Pump)		
Mechanical	Clockwise	0.5:1**
Electrical	Clockwise	0.5:1**

Information regarding approved accessories will be furnished upon request from the Service Division.

MAGNETO OIL DRAIN In order to provide adequate drainage for the late type magnetos, and at the same time prevent oil from covering the nacelle and cowl if the engine or magneto oil seals fail, the plug should be removed from the bottom of each magneto, and a suitable drain tube should be attached and led outboard. In some magnetos this plug has been drilled so it need not be removed. However, a hose connection may be slipped over the end of the plug, and the drainage led outboard.

* The dual accessory drive intermediate gears may be changed to obtain a speed ratio of 1.687:1 if desired.

** The tachometer drive gear shafts may be changed to obtain a speed ratio of 1:1 if desired.

FUEL SYSTEM When an engine is installed in an airplane, the fuel lines should be checked to see that they are attached to the proper connections on the fuel pump. The pump discharge should be connected to the carburetor. If the fuel pump does not incorporate an internal pressure relief valve, the pressure relief line should be piped back to the fuel supply system. The fuel pump drain should be led outboard through a suitable tube.

LUBRICATION SYSTEM The oil inlet and outlet lines should be attached to the connections marked IN and OUT which are provided on the oil pump.

Oil inlet temperature may be measured at the pump connection as shown on the installation drawing.

The oil pressure line should connect the pressure gauge on the instrument board with the pressure connection on the crankcase rear cover.

The vent from the oil tank should be piped into the engine crankcase, entering the rear section through the tapped hole as indicated on the installation drawing. With the vent installed in this manner, oil will not be spilled from the tank during stunt maneuvers of the plane.

PROPELLER GOVERNOR Check the governor for freedom of movement, and if any binding is observed, this should be investigated and corrected before installation.

Mount the governor on the engine mounting boss. The pilot should enter the opening on the mounting boss freely. The governor stud nuts should then be drawn down finger tight, the governor head removed, and the pump gears checked for freedom of movement to the extent of the backlash between the governor drive and the engine drive as the nuts are tightened. The nuts should be drawn down evenly to the proper torque value. The propeller should then be rotated to at least three positions and the governor checked for freedom of movement at each point.

If it is impossible to obtain freedom of movement in the governor after taking the above precautions, the driving mechanism in the engine should be investigated.

PROPELLERS Complete information on the installation of propellers is given in the publications supplied by the propeller manufacturers.

INSPECTION OF ENGINE INSTALLATION After installing the engine in the airplane, the following items should be checked before the cowl is placed in position:

1. Check all the nuts and bolts on both the engine and the mount to see that they are tight and are properly locked. Do not draw up any farther on bolts and nuts already secure.
2. Check the propeller hub nut to be sure it is tight and properly locked.
3. Operate the throttle and mixture controls, and inspect the levers on the carburetor to make sure that they hit the stops on both ends of the travel without restriction.
4. Operate the two-speed clutch control and inspect for full travel of the valve.
5. Check the priming line, pump, and valve for proper operation.
6. See that the ground wires are connected to the magnetos and ignition switch.
7. Operate the hand pump to obtain pressure in the fuel system and inspect to see that there are no leaks in the fuel lines, or at the fuel line connections. Do not pump up more fuel pressure than the maximum fuel pressure quoted for the carburetor used on the installation.

If all items of the above inspection have been found to be satisfactory, the cowl should be installed, and the airplane should be prepared for flight test.

EXHAUST GAS ANALYZER An exhaust gas analyzer, used for indicating the fuel air mixture ratio, is recommended for use on C9-GC engines. This indicator provides a means of checking the mixture ratio in flight. Information concerning installation of the unit may be had by request from the Service Division.

MANIFOLD PRESSURE GAUGE LINE The accumulation of small quantities of oil or water in the manifold pressure gauge line will result in incorrect manifold pressure gauge readings which may lead to serious damage to the engine.

It is recommended that a valve be installed in the manifold pressure gauge line at a convenient location in the cockpit for the purpose of blowing out the line to remove any accumulation of oil or water. It is recommended that the valve be opened for a period of ten to fifteen seconds at regular intervals while the engine is idling to clear out the line.

FUEL AND OIL LINES The fuel line should be as simple as possible and free from vertical bends in which air pockets can form. It is recommended that all fuel and oil connections between different units in the installation, which might vibrate, be made with a short length of gasoline and oil-resisting rubber hose, using a connection designed to prevent actual contact of the hose with the fuel in the lines. When a torque meter is used, it is recommended that the line from the torque meter to the gauge be of two lengths of copper tubing, with a short piece of flexible high pressure hose connecting two lengths to provide for movement of the engine on its mounts. Particular attention is called to this part of the installation due to the high pressures involved. With cold operating conditions, the oil in the pressure gauge lines may become so thick as to give slow and incorrect oil pressure readings. Under these conditions, it is recommended that an S.A.E. 10-W oil of good quality, having a viscosity of approximately 40 at 210 deg. F. (99 deg. C.) be used in the oil pressure gauge lines for cold weather operation. After the oil pressure gauge line is filled with this oil, all connections should be kept tight to prevent the oil from running out. During engine operation, engine oil gradually mixes with the light oil in the gauge lines. Consequently, the oil gauge lines should be refilled with light oil whenever gauge operation becomes sluggish.

Only the best copper tubing or metal hose should be used in the construction or replacement of the fuel and oil lines. If copper tubing is employed, the following recommendations are of importance:

1. Non-flexible lines should be made of soft, annealed, seamless copper tubing of the finest quality.
2. The entire tube should be annealed both before and after bending. If the bend is unusually severe, it is desirable to anneal the tube frequently during the bending.
3. Hose connections and clamps should be of the best quality obtainable. In a properly

made connection, the ends of the tube are square and are brought close together inside the hose. Remove all burrs from the ends of the tubing.

4. All lines must be braced against vibration and wear. Vibration can cause failure in an otherwise seemingly well-constructed line.

If metal hose is to be used for some of the lines, the following precautions should be observed:

1. In sweating on fittings and unions at the ends of the lines, take particular care to make a tight joint and to provide as large an area of contact as possible.
2. Do not twist the hose in tightening the connections.
3. Protect the hose against chafing at all points. A slight amount of chafing can soon start a leak.
4. Support the lines well, especially near the ends where connections may be loosened by the sagging weight.

All lines, whether of copper tubing or metal hose, should be as short and straight as possible to avoid the formation of air locks.

The fuel lines in particular must be free of vertical bends where air pockets or vapor lock might form.

Care should be exercised to see that all fuel lines are shielded insofar as is possible from all sources of heat, since the possibility of vapor lock is greatly reduced by a reduction in fuel line temperatures.

For service in cold weather, the oil lines should be covered with some form of lagging. This assists in maintaining a higher oil temperature and a correspondingly higher rate of circulation.

CHAPTER IV

STARTING AND NORMAL OPERATION

FOR fuel and oil requirements, limitations of r.p.m., power, temperatures, pressures, etc., consult airplane or engine specifications. Do not exceed these limitations.

Instructions herein are for operation under normal climatic conditions. Suggestions for operation in extreme temperature conditions may be obtained upon request from the Service Division of the Wright Aeronautical Corporation.

PRE-OILING Improved performance and extended service life of engine parts, particularly master rod bearings, may be obtained by insuring that all pressure-fed parts of an engine receive a sufficient quantity of oil immediately upon starting.

It is recommended that pre-oiling be used when starting a new engine in an airplane for the first time, when starting a newly overhauled engine on a test stand or in an airplane, or when first starting an engine which has been treated for storage.

Pre-oiling is accomplished by filling the oil passages of the engine with oil under pressure before starting, so that lubrication of parts may be obtained as soon as the engine is started. To fill the oil passages of the engine it is necessary to pump oil from an external source into the engine while the crankshaft is being rotated. A portable hand pump fitted to a suitable container, or, where pre-oiling is practiced on a large scale, a portable rig fitted with an electrically driven pump, a container, and a heating element may be used for forcing oil into the oil passages of the engine.

To pre-oil the engine, proceed as follows:

1. Fill the oil tank to its normal level.
2. Remove the oil inlet line connection at the oil pump and drain approximately one gallon of oil to insure that no air remains in the line.
3. Reinstall the oil inlet line to the oil pump.
4. Remove the quarter-inch pipe plug from the left side of the oil pump body. Remove the oil pump check valve, if not already removed.
5. With the ignition switch in off position, and the carburetor mixture control in idle cut-off position, turn the engine over by hand until sufficient oil is expelled through the quarter-inch pipe tapped hole to indicate that no air remains in the oil pump.
6. Connect the pre-oiling pump to a fitting inserted in the quarter-inch pipe tapped hole, using a piece of flexible tubing. This should be a tight connection that will not blow off when forcing oil into the engine. Pump approximately one and one-half gallons of hot oil at 100 deg. F. (38° C.) into the engine while it is being turned over. For this operation use only clean engine oil of the brand on which the engine is to operate.
7. Remove the pre-oiling pump and install the quarter-inch pipe plug. Lockwire the pipe plug after tightening.

It is recommended that the engine be started as soon as possible after pre-oiling.

FILLING When a Bendix-Stromberg carburetor is to be used for the first time after installation, or after it has been drained, this procedure should be followed: Open the tank fuel valve. Set the mixture control at automatic rich and the throttle half open. Operate the hand pump slowly to raise the fuel pressure to 4 lbs. per sq. in. (0.28 kg per sq cm). Continue to operate hand pump until a small amount of fuel runs from the supercharger drain valve.

A special condition exists when the carburetor is partly filled with air. The rate at which fuel may enter the second regulator chamber and the fuel control body is held to idling rate, causing the carburetor to fill slowly. Since there are no vents in the system beyond the second regulator chamber, all included air must escape through the nozzles causing the engine to stop after be-

ing started. To eliminate this condition, remove the vent plug from the second chamber of the regulator and work the hand pump until the fuel stands level with the plug opening.

The usual filling time for the carburetor is one minute.

COLD WEATHER PRECAUTIONS In extreme cold weather it may be necessary to pre-heat the oil before starting. A great deal of time can be saved by draining the oil from the tanks as soon as operations for the day are concluded and before the oil has cooled off. If left in the tank overnight, the oil may become so viscous as to require considerable time to drain.

In cold weather it is also advisable to have some sort of lagging on the external oil lines to and from the tank. This will result in higher oil temperature at cruising speed and will decrease the danger of stoppage due to congealed oil. A layer of asbestos cord, shellacked, and then wrapped with friction tape provides very good insulation. Lacking asbestos, several layers of ordinary packing cord can be used.

A large sized oil pressure gauge line is essential in cold weather to obtain an immediate indication of any pressure variation in the engines. Refer to the chapter on Installation regarding the use of light oil in gauge lines.

OIL DILUTION The oil dilution system consists of a valve which, when open, admits raw gasoline to the oil inlet line of the engine, reducing the viscosity of the oil in the engine and oil system. In cold weather when a temperature less than 23 deg. F. (—5 deg. C.) is expected to prevail at the start, the oil dilution system should be employed to facilitate the starting procedure. If the engine heat is excessive while diluting the oil, the heat may evaporate the fuel out of the oil, leaving the viscosity of the oil in the engine unchanged. The engine should therefore be idled with oil cooler shutters and cowl flaps in their maximum cooling positions until the cylinder head temperatures are below 149 deg. F. (65 deg. C.) and the oil-in temperature below 100 deg. F. (38 deg. C.). Should experience indicate that this does not provide sufficient cooling, the engine should be shut down for a short time and then restarted before operating the oil dilution system.

To operate the oil dilution system, run the engine at a speed of approximately 1000 r.p.m., open the oil dilution valve for a period varying from one to four minutes as determined by experience, and then stop the engine by moving the mixture control to cut-off position. The proper length of time is dependent on the anticipated temperature at the start, the amount and grade of oil in the oil system, and the characteristics of each installation. In all cases, leave the oil dilution valve open until the engine stops, then close the valve and turn off the standard fuel supply valve. Turn the ignition switch to off position.

When starting an engine whose oil system has been diluted, a normal start and warm-up should be made. The oil when diluted will usually permit the starter to turn the engine at a fairly high rate of speed without the necessity of preheating the oil. During the warm-up period, the fuel will gradually evaporate as the oil temperature rises. After starting, if a heavy viscous oil is indicated by oil pressure that is too high or by oil pressure that fluctuates or falls back when the engine r.p.m. is increased, the dilution valve is sometimes operated to correct this condition. This is not considered good practice, but in the event of an emergency it may be resorted to, provided the oil dilution valve is operated intermittently and not continuously.

PRE-FLIGHT INSPECTION

A. Before starting an engine for the first time after installation, the following procedure should be observed.

1. Check the magneto ground wires for proper connection to magnetos and ignition switch. See that the terminal marked "Grd." on the ignition switch is connected to the engine crankcase. See that all connecting wires are in good condition and that the insulation is not broken at any point.
2. Check all bolts and nuts on both engine and mount to see if they are tight and properly locked.
3. Check the propeller hub nut for tightness and proper locking.
4. Check the pressure gauges, tachometer, thermometers, and thermocouples for proper connection.
5. Check the primer pump, lines, and connections for working order and proper connection.
6. Check throttle and mixture controls, and clutch controls of two-speed engines, for full travel and proper connection .98 inch

(22,8 mm) minimum travel of the clutch valve stem should be obtained.

7. Open fuel cocks and operate hand pump. Check all fuel lines for tight connections.

B. Before every flight, check the following items:

1. Fill the oil tank with an ample quantity of oil for the run, and see that all oil lines are open.
2. Fill the gasoline tanks with the proper grade of gasoline as specified in the table of Engine Characteristics of this manual.
3. Operate the throttle and mixture controls to see that they function smoothly over their entire operating range.
4. Operate the two-speed clutch control on two-speed engines and inspect for full operation of the piston valve.

STARTING INSTRUCTIONS

1. Immediately before starting, head the airplane into the wind and pull the propeller through by hand for at least three complete revolutions. If it requires abnormal effort to move the propeller, remove the spark plugs from the lower cylinders to determine whether liquid has collected in the cylinders.

When the propeller is rotated slowly by hand, the dynamic dampers fall against stops on the crankshaft, when the counterweights are raised above the horizontal position. The noise of these dynamic damper counterweights coming in contact with the stops is in some cases clearly discernible. This information is brought to the attention of operators in order to prevent unnecessary investigation to determine the source of this noise.

WARNING: The presence of any quantity of liquid in the combustion chamber of an engine is likely to cause serious damage. It is therefore urgently recommended that all operators take steps to have engines pulled through three complete revolutions by hand before they are started. The Wright Aeronautical Corporation will not assume any responsibility for engines which are damaged due to the presence of liquid or any other obstruction in a cylinder.

2. Position of Controls:

a. Fuel Supply Cock ....On
b. Ignition Switch ....Off
c. Throttle ....Set for 1000 r.p.m.
d. Mixture Control ....Idle Cut-Off
e. Clutch Control (Two speed engines) .....Low
f. Propeller ....Low Pitch (High r.p.m.)
g. Carburetor Air Scoop ....Cold
h. Oil Cooler Shutter ....Closed
i. Exhaust Gas Analyzer ....On
j. Cowl Flaps ....Open

In extremely cold weather, if the temperature of the oil is less than 20 deg. F. (-7 deg. C.), it is recommended that the oil be preheated prior to starting. If properly diluted at the last stop, the oil requires no preheating.

3. Obtain the proper fuel pressure with hand or electric pump. The correct pressures for the various carburetors are as follows:

Bendix Stromberg Injection 13-18 lb. per sq. in.
Holley .... 6- 7 lb. per sq. in.
Chandler-Evans .... 6- 7 lb. per sq. in.

4. Engage starter

5. After the propeller has turned two revolutions, switch ignition On.

6. Operate booster ignition and primer simultaneously. Pump the hand primer approximately five strokes or engage a solenoid type of primer for several seconds. It is difficult to predict the exact number of strokes required to prime, as it depends on the installation, temperature, and other such conditions. Therefore, the amount of priming may be varied as indicated by experience. If the engine is warm, priming may not be necessary.

NOTE: **In the event a ballistic or a plain inertia type starter is used, operate primer as necessary and turn ignition switch on prior to engaging starter. However, do not alter the procedure when using a direct cranking inertia starter.**

7. As the engine starts to fire, move the mixture control to automatic rich if a Stromberg Injection carburetor is used. With a Holley or Chandler-Evans carburetor, move the mixture control to full rich.

8. Release booster ignition switch.

9. If engine refuses to start after 10 to 20 revolutions, let starter cool and repeat the foregoing procedure.

10. Shut down if the oil pressure does not reach 40 lb. per sq. in. within 10 seconds after starting.

A priming charge cannot be obtained by pumping the throttles of Holley, Chandler-Evans, or Stromberg Injection carburetors since they are not mechanically linked to the accelerating pump. Do not prime by pouring raw gasoline

into the cylinders through exhaust ports or spark plug bushings. Do not overprime. Overpriming may prevent any firing taking place or may result in only a few explosions, torching, and white fog from the exhaust stack. If the engine becomes overprimed, open the throttle and turn the engine over several revolutions until it has cleared out. Make certain that the ignition switch is off during this period. When cleared, return the throttle to the 1000 RPM position.

The mixture control should always be left in idle cut-off position when the engine is shut down. Do not operate the hand pump excessively when the mixture control of a Stromberg Injection carburetor is out of idle cut-off position, as fuel is discharged into the engine when the mixture control is in any other position.

A few instances have been encountered where the fuel has leaked through the primer pump and into the intake passages, thus filling the lower cylinders with raw fuel. It is absolutely necessary that the primer shut-off valve be closed except when the pump is being used. Check to make certain that this valve is working properly.

NOTE: **After prolonged shut-down or new fuel line installation, the following should be observed:**

Open throttle with mixture control in full rich. Turn fuel pressure on. Observe the fuel pressure gauge reading. Observe any fuel leaks. Push mixture control to Cut-Off immediately if fuel is discharged from the supercharger drain valve. If flow of fuel from drain does not cease, shut off fuel supply and investigate cause.

To insure against fires, over-priming, and flooding of the lower cylinders, an engine should not be started with the mixture control in the Full Rich position, nor should it be primed when the crankshaft is not being turned.

CAUTION: **If an engine is being started for the first time after being treated for storage, or if the engine is new, make sure that the instructions in the section entitled SERVICING NEW OR STORED ENGINES have been followed. The engine should then be started and run at approximately 1000 r.p.m. until all the rust preventive has been removed. If it becomes necessary to stop the engine during the preliminary start, the spark plugs may become fouled by condensation. It will then be necessary to clean and test the spark plugs before repeating the starting procedure.**

WARM-UP

1. A thorough warm-up is recommended. During the warm-up, leave the carburetor air heat control and cowl flaps in the same position as for starting. Leave oil cooler shutters in closed position until oil reaches satisfactory operating temperature; then open shutters as required. Run the engine at 1000 r.p.m. until the oil pressure indicates approximately 45 lb. per sq. in. (3,16 kg. per sq. cm.).

2. Gradually open the throttle to 1200 r.p.m. and continue the warm-up until the oil temperature reaches 130 deg. F. (55 deg. C.), or in cold weather, until an oil temperature rise of 10 deg. F. (6 deg. C) minimum is obtained. This is an indication that the oil is circulating properly through the engine and oil lines.

3. Watch the oil pressure gauge for fluctuations in pressure caused by air trapped in the oil lines. Any air so trapped should be allowed to escape by extending the warm-up period until the oil pressure stabilizes.

4. Be sure the oil cooler shutters are closed to aid in warm-up.

5. The engine cowl flaps should be open. Closing the cowl flaps will not shorten the warm-up period and it may result in cylinder fin cracking because of the difference in temperature between the forward and rearward portions of the fins. Closing the cowl flaps may also result in burning of the ignition system insulation.

PERFORMANCE CHECK

1. After the engine has been given a thorough warm-up, open the throttle to not more than 30 in. Hg manifold pressure and with an engine speed not in excess of 2000 r.p.m. check the temperatures and pressures of the fuel and oil, and the performance of each magneto. The mixture control should remain in the automatic rich position.

2. If the oil pressure drops when the throttle is open, continue the warm-up at 1200 r.p.m. if the oil pressure is not within the specified range, throttle the engine and adjust the oil pressure relief valve in the body of the oil pump.

3. Check magneto and spark plug performance by moving the ignition switch so as to produce engine operation on each magneto. The normal drop of r.p.m. resulting from this change in engine operation is 50 to 75 r.p.m. If a greater drop in r.p.m. is obtained, check for misfiring of one or more cylinders caused by the malfunctioning

of spark plugs or magneto. On installations which incorporate a constant speed propeller, be sure that the propeller is set in low pitch or held in a fixed position so that any drop in r.p.m. will not be compensated for by the propeller. This check should be made in as short a time as practicable since continued running on one magneto may cause serious detonation.

4. On two-speed engines, the clutch should be checked for proper functioning. Changes from one supercharger ratio to another should be made quickly, without pausing between the low and high positions. The supercharger control must be locked at the extremity of its travel in either ratio to ensure complete engagement of the clutch.

To check the two-speed supercharger, roller clutch or plate clutch type, set the propeller governor in the full low-pitch (high r.p.m.) position. Close the throttle completely, move the supercharger control valve to high position and lock. Open the throttle to obtain not over 30 in. Hg manifold pressure. When the engine speed has stabilized, observe the manifold pressure. Without moving the throttle, shift the supercharger control valve to the low-speed position. A sudden decrease in manifold pressure is an indication that the two-speed supercharger drive is operating properly.

The supercharger clutches should be shifted from low to high and back again at the following intervals for ground checks:

a. Immediately following engine warm-up, prior to the first flight each day. This check should be conducted only after reaching a minimum oil pressure of 50 lb. per sq. in. and an oil temperature of 38 deg. C.

b. Following the last flight of the day prior to stopping the engine.

TAKE OFF AND CLIMB

1. Set the oil cooler shutters to full open position. Unless severe atmospheric ice is present, such as sleet, always set the carburetor air scoop control in the cold position during take-off. If atmospheric ice is present, remove any ice that may be present in the carburetor by setting the carburetor air scoop control in the full hot position, but before take-off, return the control to the cold position.

It is not advisable to take-off with cylinder head temperatures below 250 deg. F. (121 deg. C.) or above 400 deg. F. (240 deg. C.).

2. Leave the mixture control in full rich if using a Holley or Chandler-Evans carburetor; leave in automatic rich if using a Stromberg injection carburetor.

3. Set the propeller governor control in low pitch (high r.p.m.).

4. Check the supercharger control to insure that the supercharger is locked in low ratio.

4. Open the throttle to the recommended take-off manifold pressure.

5. Take the airplane off the ground, and after not more than one minute of operation at take-off power, throttle back to rated or cruising power for climb. Take-off power may be used for a maximum of five minutes in the event of an emergency.

RATED POWER CLIMB

When reducing engine power, always reduce the manifold pressure first, then reduce the propeller speed; when increasing the engine power, always increase the propeller speed first, then increase the manifold pressure. Never make these changes in any other order.

1. Adjust the manifold pressure to that specified for rated power by retarding the throttle. With increase of altitude, throttle must gradually be opened until at critical altitude it is fully open.
2. Adjust the r.p.m. to that specified for rated power by setting the governor control to rated r.p.m.
3. The mixture control position is as follows:
   a. Holley or Chandler-Evans carburetor—Full Rich

   b. Stromberg carburetor—Automatic Rich
4. Adjust the oil cooler shutters to give an oil inlet temperature within the specified limits.

CRUISING POWER CLIMB

1. Adjust the manifold pressure to the value specified for cruising, using the same procedure as for rated power climb.
2. Adjust the propeller to give cruising r.p.m., using the same procedure as for rated power climb.
3. The mixture control position is as follows:
   a. Holley or Chandler-Evans carburetor—Full Rich
   b. Stromberg carburetor—Automatic Rich

4. Adjust the oil cooler shutters to give an oil inlet temperature within the specified limits.

LEVEL FLIGHT—RATED POWER

1. Adjust the manifold pressure to that specified for rated power.
2. Adjust the propeller governor to give rated r.p.m.
3. The mixture control position is as follows:
   a. Holley or Chandler-Evans carburetor—Full Rich
   b. Stromberg carburetor—Automatic Rich
4. Adjust the oil cooler shutters to give an oil inlet temperature within the specified limits.

LEVEL FLIGHT—CRUISING POWER

1. Adjust the manifold pressure to that specified for cruising power.
2. Adjust the propeller governor to give cruising r.p.m.
3. The mixture control position is as follows:
   a. Holley or Chandler-Evans—Cruising Lean
   b. Stromberg carburetor—Automatic Lean
4. Adjust the oil cooler shutters to give an oil inlet temperature within the specified limits.

If an emergency arises which necessitates increasing the power to some value between rated power and maximum horsepower recommended for cruising, the mixture should be enriched, the propeller governor control should first be adjusted to give an increased r.p.m.; then adjust the throttle control to give an increased pressure. In general, between the limits of rated power and maximum power recommended for cruising the variations in manifold pressure and r.p.m. should be proportionate. This point should be kept in mind when operating with constant speed propellers as the propeller control will require readjustment whenever a change is made in engine power output.

DESCENT TO ABOUT 500 FEET ABOVE AIRPORT

1. For descent at rated power, no change in controls from level flight at rated power need be made except that it is necessary to close the throttle gradually as required to maintain specified rated manifold pressure.
2. For descent at cruising power, no change need be made from the setting of propeller control from level flight at cruising power. The throttle control must be gradually closed as altitude decreases, and the mixture must be enriched.
3. Under icing conditions, adjust carburetor air scoop to hot position.

AT 500 FEET ABOVE AIRPORT

1. Move the throttle control lever gradually toward closed position and set propeller governor for rated r.p.m.
2. The mixture control position is as follows:
   a. Holley or Chandler-Evans—Full Rich
   b. Stromberg carburetor—Automatic Rich
3. Set the carburetor air scoop in cold position except under icing conditions when setting is left as for descent.
4. The oil cooler shutter should be returned to wide open position to accommodate the necessary heat dissipation in the event that full emergency power is required. In such an emergency, if the scoop control is in the hot position, turn control to cold position immediately after opening throttle.

STOPPING THE ENGINE

1. The engine is apt to be cooler at the end of the glide and after landing than it will be after idling. It is consequently advisable to shut the engine down as soon as possible after landing if the cylinder heads are found to be below 300 deg. F. (150 deg. C.).
2. If the engine has been warmed up by taxiing, idle at 600 to 800 r.p.m. until the cylinder head temperature drops below 300 deg. F. (150 deg. C.). If absolutely necessary to stop the engine before cooling off properly, the engine should be throttled down to at least 1000 to 1200 r.p.m. before stopping.
3. The propeller position for stopping an engine will depend upon the conditions to be encountered after stopping and upon the type of propeller used. Electrically controlled propellers may be stopped in low pitch at any time. For normal stopping, when using a hydro-controlled propeller, in warm weather, or where the engine is to be started again before the oil in the cylinder of the adjusting mechanism will have time to congeal, the propeller may be left in the low pitch position. Where an engine is to be left overnight, propeller controls should be put in high pitch and engines run until the blades have shifted into high pitch, before stopping the engines.

With a hydro-controllable propeller, if the propeller is left in low pitch on stopping the engine in cold weather, the oil may congeal in the cylinder and prevent shifting to high pitch.

4. Before stopping, increase the speed to 1000-1200 r.p.m. and hold for ½ minute to obtain optimum scavenging of oil from the engine. Move the mixture control lever to cut-off position. The engine should stop in a few seconds. The control should not be moved out of the cut-off position after stopping the engine.
5. Turn the ignition switch off after the propeller stops turning. Fuel tank valves should be closed when engine is not being operated.
6. If used, turn the exhaust gas analyzer off.
7. Do not move the propeller until the engine has cooled thoroughly.

It should be noted that if an exhaust gas analyzer is used in the airplane it should not be turned off until after the engine has stopped. This is recommended because of oil collecting on the bridge coils if the wires are not hot. Unless the analyzer is left on, it may be inoperative or out of adjustment for a period of as much as two hours after restarting.

FEATHERING The method of feathering the Hamilton Standard Hydromatic and Curtiss electric propellers in flight during an emergency is as follows:

1. Throw the feathering switch to the feather position.
2. Close the throttle.
3. Move the mixture control to the idle cut-off position.
4. Turn off the fuel supply.
5. Turn off the ignition switch after the propeller stops turning.

UNFEATHERING A. The method of unfeathering the Hamilton Standard Hydromatic Propeller in flight during an emergency is as follows:

1. Set the governor control to high pitch or minimum r.p.m. position.
2. Turn on the fuel supply.
3. Turn on the ignition switch.
4. Set the throttle and mixture controls to their normal starting positions.
5. Close the propeller control switch and keep it closed until the engine is running at approximately 1000 r.p.m.

CAUTION: **Check the engine oil pressure. If no oil pressure is indicated within a few seconds after the engine starts windmilling, refeather the propeller and keep the engine out of operation until it can be properly repaired.**

6. Release the unfeathering switch allowing the propeller to return to the control of the governor.
7. Adjust the throttle and governor controls to give the minimum r.p.m. and manifold pressure which will allow the engine to warm-up properly in a reasonable length of time.

NOTE: **This warming-up procedure varies with different airplane models because of air speed and engine installation.**

8. At the completion of the warm-up, set the governor and throttle controls to give the desired speed and manifold pressure.

CAUTION: **The maximum speed and power that may be used following warm-up after unfeathering the propeller depends upon the type of feathering fluid used.**

B. The method of unfeathering Curtiss electric propellers in flight during an emergency is as follows:

1. Set the governor control to high pitch or minimum r.p.m. position.
2. Turn on the fuel supply.
3. Turn on the ignition switch.
4. Set the throttle and mixture controls to their normal starting positions.
5. Throw the feathering switch to the normal position and hold the selector switch in increase r.p.m. position.

CAUTION: **Check the engine oil pressure. If no oil pressure is indicated within a few seconds after the engine starts windmilling, refeather the propeller and keep the engine out of operation until it can be properly repaired.**

6. Hold the unfeathering switch in increase r.p.m. position and open the throttle until the engine is operating at the minimum speed and manifold pressure at which it can be properly warmed up in a reasonable length of time.

7. Move the selector switch to automatic position.
8. At the completion of the warm-up, set the governor and throttle controls to give the desired engine speed and power.

GENERAL Always take off in the low supercharger ratio, regardless of the altitude of the airport at which the engine is being operated. The engine should be operated in the low-speed ratio at altitudes up to the low-speed ratio critical altitude for the power being used. During such operation, the engine should be operated in the same manner as a single-speed supercharger engine.

During flight, the high-speed ratio may be used above critical altitude to obtain maximum speeds and rates of climb, as previously specified in the operating instructions. The high-speed ratio should not be used for cruising at altitudes at which cruising power is available in low-speed ratio, because in high-speed ratio the fuel economy is inferior to that obtainable in low-speed ratio.

Changes from one speed ratio to another should be made quickly. The oil control valve must be locked at the extremity of its travel in either ratio to ensure complete engagement of the clutch.

For detailed instruction on operating technique, see Flight and Ground Operating Instructions.

FLIGHT When shifting from low- to high-speed ratio, operate the two-speed supercharger control in the following manner, carefully observing the proper sequence:

1. Set the mixture control in automatic rich or full rich position.
2. Partially close the throttle so that the desired high-speed supercharger manifold pressure will not be exceeded. (The amount of closing will be determined by experience to give the desired manifold pressure or less after the shift has been made.)
3. Move the oil control valve rapidly from low position to high position and lock.
4. Readjust the throttle setting if the manifold pressure is not at the desired value for high-speed ratio operation.
5. Readjust the r.p.m. setting only as necessary to obtain desired power.
6. Readjust the mixture control to obtain the desired setting.

When shifting from high- to low-speed ratio, operate the two-speed supercharger control in the following manner:

1. Set the mixture control in automatic rich or full rich position.
2. Quickly move the oil control valve to the extreme low-speed ratio position and lock before moving throttle.
3. Set the desired manifold pressure by means of the throttle.
4. Readjust the r.p.m. setting only as necessary to obtain desired power.
5. Readjust the mixture control to obtain the desired setting.

During flight, wait at least five minutes after changing speed ratios before making another speed ratio change, in order to provide opportunity for dissipation of the heat generated during clutch engagement.

MIXTURE CONTROL The mixture control, though primarily an altitude adjustment, may be used for the economy of fuel at cruising speeds but should be kept full rich for Holley or Chandler Evans carburetors, and in automatic rich for Stromberg carburetors, during operation at maximum throttle position. Full rich position on the Stromberg carburetor is used only in an emergency. Extreme care should be exercised so as not to overheat the engine by too lean a mixture. Excessive leaning of the mixture in flight when operating at rated power is generally accompanied by a rise in cylinder temperatures. It is therefore necessary to exercise every precaution in the use of the mixture control. In general, during level flight, the Stromberg carburetor may be adjusted over the range from automatic rich to automatic lean, and the Holley and Chandler Evans may be adjusted from full rich to cruising lean.

The use of the mixture control is considered proper at all cruising altitudes in level flight subject to a maximum cylinder head temperature restriction of 400 deg. F. (205 deg. C.) at cruising power and 425 deg. F. (218 deg. C.) at rated power, and subject to the requirement when using a manually controlled constant speed propeller that the engine r.p.m. shall not drop more than 10 to 20 r.p.m. at a constant throttle opening.

In general, if the mixture control has been used during climb, it is advisable to richen up

before adjusting the throttle for level flight. This procedure is recommended to avoid the possibility of cutting out the engine due to an excessively lean fuel-air ratio. After setting the throttle for level flight the mixture control should again be adjusted as necessary for economical cruising. Whenever engine power is increased, the mixture should be richened before the manifold pressure is increased.

The mixture control may be used in descent in accordance with the instructions given above, but as the mixture gradually leans out during descent, it is advisable to operate on the rich side of the desired setting during this condition.

Detonation must be guarded against when operating conditions are selected which require low r.p.m. and manifold pressures which are disproportionately high.

CARBURETOR AIR SCOOP OPERATION Since the Stromberg injection carburetor, the Holley CG, and the Chandler Evans carburetors are inherently non-icing, it is unnecessary to use a heater. However, under atmospheric icing conditions, that is, a wing icing condition, it is possible that ice may form in the carburetor air scoop or on the screen at the top deck of the carburetor in such quantities as to reduce the engine power. It is therefore necessary with these carburetors to supply a moderate amount of preheat to eliminate this type of ice. This can be accomplished by providing a valve in the air scoop which will close off the scoop cold air supply and take the warm air from behind the cylinders and inside the engine cowling.

With this arrangement of preheat and using a non-icing carburetor, measurement of the carburetor air temperature or mixture temperature is not necessary when an outside air temperature bulb is available on the airplane, and provided it is demonstrated that the preheat obtained is not in excess of 60° F. (15.5° C.) with full heat on and operating at rated power. Measurement of the carburetor air temperature is recommended when the heat supply is in excess of the above limitation, as, in this case, the carburetor air temperature gauge will serve as a definite protection to the engine for preventing the use of excess carburetor heat. With this arrangement of preheat, provision for measuring mixture temperature is not necessary.

FUEL SUPPLY VALVES To avoid possible damage to engines resulting from operation at excessively lean mixtures, it is recommended that the precautions given below be observed by all operators.

Whenever the fuel supply to an engine is shifted from one fuel supply tank to another, the mixture control of the engine should be in full rich or automatic rich position. The shifting of the fuel supply should be made as quickly as possible. An engine fuel supply tank should not be permitted to run dry before the shift is made to an alternative fuel supply tank.

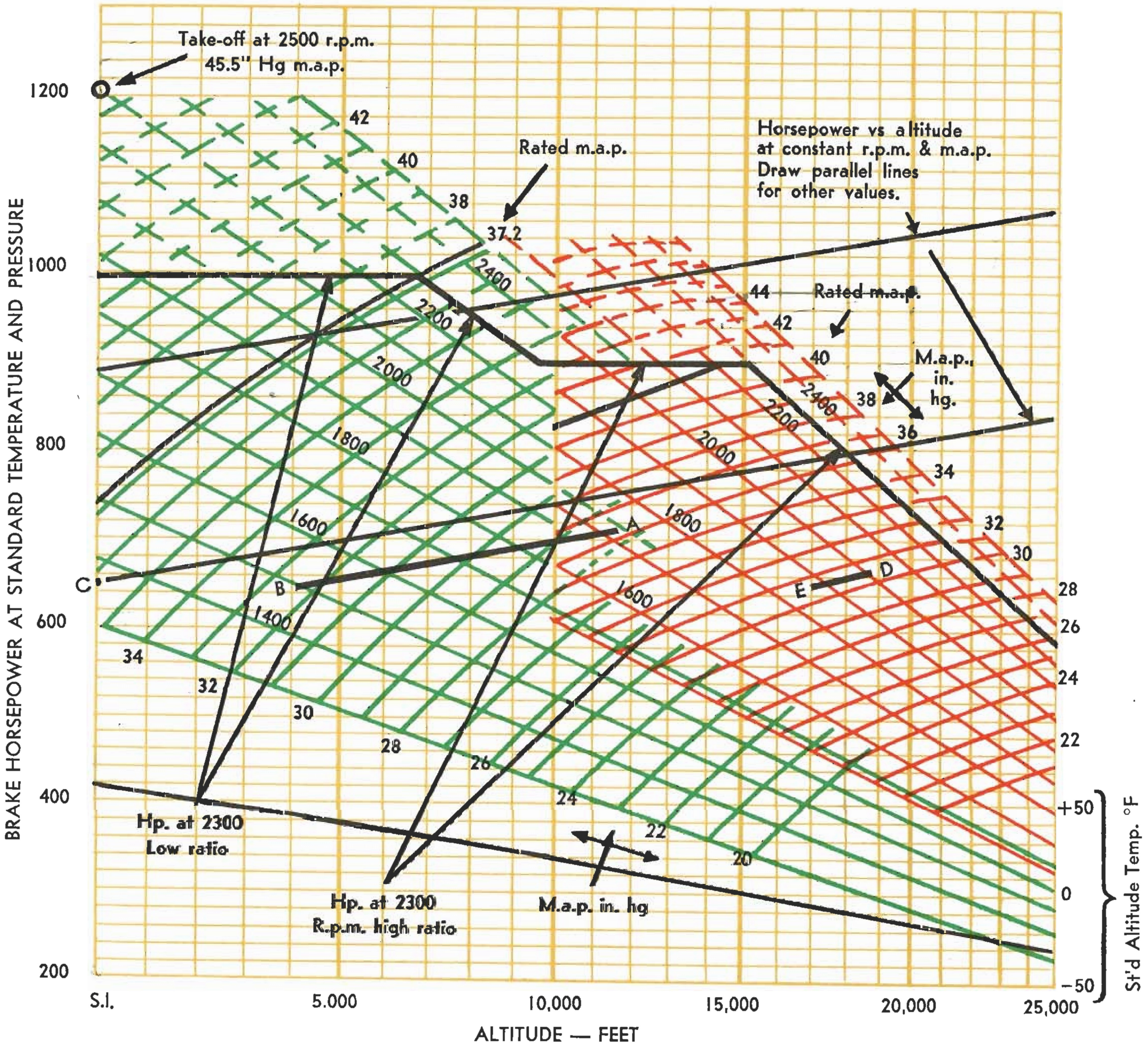
RUNOUT ON UNLEADED FUEL If the engine is to be shut down for a period to exceed 48 hours, it should be operated at 40% to 50% of normal rated r.p.m. (but in no case less than 1000 r.p.m.) on the propeller load with 73 or 65 octane fuel containing no tetraethyl lead for a period of one-half hour. This is necessary to assist in avoiding the corrosion caused by tetraethyl lead.

Before stopping the engine, run it between 700 and 800 r.p.m. long enough to permit the cylinders to cool to a miximum temperature of 250° F. (122° C.). Increase the speed to 1000-1200 r.p.m. and hold for ½ minute to obtain optimum scavenging of oil from the engine. Then move the mixture control to the fuel cut-off position and turn the ignition switch to the off position.

FUEL SPECIFICATIONS In the selection of fuel for aviation engines, the operator is faced with a problem which requires careful consideration. An inferior fuel will cause serious damage to the engine and a mediocre grade will cause continuous small troubles which are often obscure when an attempt is made to trace them to their source. The use of a high grade product, on the other hand, will be found to improve the reliability, power, and fuel economy of the engine and will, in the long run, decrease the cost of operation.

Gasoline specifications are included in the appendix of this book and will be of assistance in selecting fuel. The operator should have the assurance of the vendor that the fuel under consideration has an anti-knock value at least equivalent to that specified in the Engine Specification and stamped on the engine data plate.

The Wright Aeronautical Corporation will not be responsible for damage to the engine when any but the specified grade of fuel is used. The use of fuel which does not meet the required specification constitutes misuse of the engine and voids the engine warranty.



Typical Wright Cyclone 9-GC Engine Performance Chart

CHAPTER V

WRIGHT ENGINE PERFORMANCE CURVES

DESCRIPTION In Wright full throttle altitude performance curves, lines representing revolutions per minute (r.p.m.) and manifold pressure are plotted against horsepower on the vertical axis and against altitude in feet on the horizontal axis. A curve of this type is shown at the end of this chapter. Engine r.p.m. and manifold pressure lines are plotted for both high and low ratio supercharger operation for engines having two supercharger gear ratios, and the curves are marked accordingly. The engine r.p.m. lines are plotted in increments of one hundred r.p.m. while the manifold pressure lines are in increments of one inch of mercury.

A line of horsepower vs. altitude at constant r.p.m. and manifold pressure is indicated on the curve. Only one such line is necessary and all other possible lines of horsepower vs. altitude at constant r.p.m. and manifold pressure are parallel to this one.

A standard temperature vs. altitude line is plotted at the bottom of most full throttle altitude performance curves.

The engine performance curves described above are designed for use with a specific engine model and cannot be used with any other model or with an engine which is not being operated in accordance with the engine specifications corresponding to the power curves. Performance curves are prepared for all commercial models of C9-GA, C9-GB, and C9-GC engines. Refer to the curve which is prepared specifically for a particular engine model to obtain performance figures for an engine of that model.

The powers as determined from the engine performance curves are subject to two and one-half per cent variation.

METHOD OF READING ENGINE PERFORMANCE CURVES When reading performance curves, it must be borne in mind that they were made up using standard altitude temperatures and pressures, that they represent engine operation using fuel-air mixtures which give best power, and that they are based on air entering the carburetor under no ramming effect.

When using a full throttle altitude curve in flight to determine the horsepower developed by the engine, proceed as follows:

1. Locate the intersecting point of observed manifold pressure and engine r.p.m. on the curve. Be sure that this point is located on the proper supercharger speed ratio section of the curve (Low or High), corresponding to the supercharger speed ratio at which the engine is being operated. Considerable error will exist in the calculated horsepower if this point is located in the wrong section of the curve.

2. Draw a line through this point parallel to the line of horsepower vs. altitude at constant r.p.m. and manifold pressure shown on the curve. Any point on this new line is at the observed manifold pressure and engine r.p.m.

3. Follow down along this line until the vertical line representing the altitude at which the airplane is being operated is reached.

4. From this point project a line horizontally to the left. Read the observed, or uncorrected, horsepower from the vertical horsepower scale at the left edge of the curve.

5. Correct the observed horsepower for variation in carburetor air temperature by adding or subtracting a horsepower correction equal to 1 per cent of the observed horsepower for each 10 deg. F. (6 deg. C.) variation in the observed carburetor air temperature from the standard altitude temperature. If the observed carburetor air temperature is less than the standard altitude temperature, add the horsepower correction to the observed horsepower. If the carburetor air temperature is more than the standard altitude temperature, subtract the horsepower correction from the observed horsepower.

Example No. 1

(Refer to Chart, p. 50)

Flight Conditions:

Manifold Absolute Pressure	28.3" Hg (71,9 cm Hg)
Engine r.p.m.	2,000
Supercharger Drive Ratio	Low (7.14:1)
Altitude	4,000 Ft. (1220 m)
Carburetor Air Temperature	26° F. (-4° C)

Locate the intersecting point of the observed manifold absolute pressure and engine r.p.m. on the section of the curve which is drawn for low supercharger ratio operation (Point A). Through this point draw a line of horsepower vs. altitude at constant r.p.m. and manifold pressure (Line AB). This line is to be drawn parallel to the line of horsepower vs. altitude at constant r.p.m. and manifold pressure which is shown on the curve. Project a line horizontally to the left from the intersection point (Point B) of the line just drawn and the 4000 ft. (1220m) altitude line. Read the uncorrected horsepower from the vertical horsepower scale as 650 (Point C).

Correct this observed horsepower for the difference between the actual carburetor air scoop temperature and the standard altitude temperature as follows:

Determine the standard altitude temperature from the standard temperature vs. altitude curve. The standard temperature at 4,000 ft. (1220m) altitude is 46 deg. F. (8 deg. C.). This gives a temperature difference of 20 deg. F. (12 deg. C.) between the standard and the observed temperatures. Determine the horsepower correction as follows:

Horsepower correction

= 1% of 650 for each 10° F. (6° C.)

= .01 x 650 x 2 = 13.0 temperature difference

Because the observed carburetor air temperature of 26 deg. F. (-4 deg. C.) is below the standard altitude temperature, add the horsepower correction to the observed horsepower.

Corrected horsepower = 650 + 13 = 663

Example No. 2

(Refer to Chart, p. 50)

Flight Conditions:

Manifold Absolute Pressure	30.5" Hg (77,5 cm Hg)
Engine r.p.m.	2,000
Supercharger Drive Ratio	High (10:1)
Altitude	17,000 ft. (5.182m)
Carburetor Air Temperature	43° F. (6° C.)

Locate the above observed manifold pressure and r.p.m. points on the section of the curve which is drawn for high supercharger ratio operation (Point D). Draw in the parallel line of horsepower vs. altitude at constant r.p.m. and manifold pressure (Line DE) as described in Example No. 1. Extend this line until it intersects the vertical line of 17,000 ft. (5.182m) altitude (Point E), and read the uncorrected horsepower (Point C) as was done in Example No. 1. It is seen that the uncorrected horsepower is again 650.

Obtain the horsepower correction as in Example No. 1. However, since the actual carburetor air temperature, 43 deg. F. (60 deg. C), is above the standard altitude temperature, 3 deg. F. (-16 deg. C), for 17,000 ft. (5.182m.) subtract the horsepower correction from the observed brake horsepower. This calculation is shown below.

Horsepower correction = .01 × 650 × 4 = 26
Corrected horsepower = 650 - 26 = 624

It should be noted that the power curves are based on best power mixture strength. Therefore, if the engine is not being operated at best power mixture strength, the determined horsepower will not be entirely correct.

It should also be noted that if air enters the carburetor under a ramming pressure (as it does in some instances), the plane may operate at a specified manifold pressure and engine r.p.m. at altitudes slightly above the full throttle critical altitude of the engine as shown on the power curves. If this is the case, then the horsepower vs. altitude at constant r.p.m. and manifold pressure line must be extended to the right beyond the full throttle critical altitude point for the specified manifold pressure and r.p.m. The observed and corrected horsepowers may then be determined as described above.

CHAPTER VI

ENGINE TROUBLES

DETERMINING the causes of engine troubles is at times rather involved due to the number of sources to which a given symptom may be attributed. The best method of "trouble shooting" is to decide first on the possible causes and then eliminate them one by one, starting with the most probable.

This table of the commonest troubles and their causes is submitted with the object of reducing wasted time and increasing the reliability of the engine.

FAILURE OF ENGINE TO START If the engine fails to start, it may be due to any one or more of the following conditions:

1. Lack of fuel.
2. Under priming or over priming.
3. Booster magneto defective.
4. Throttle opening incorrect. The throttle should be set to give approximately 1000 r.p.m. when the engine starts to fire regularly.
5. Ensure that the mixture control is in idle cut-off for engines using a Bendix-Stromberg injection carburetor.
6. Defective spark plug ignition terminal. Examine for the presence of moisture and dirt and for defects or cracks in the insulating sleeve.
7. Defective ignition wire. Examine ignition wiring for wear, breaks, and incorrect connections.
8. Dirty spark plugs. Check the spark plugs for proper functioning. Clean and set gaps (.012 inch, 0,304 mm).
9. Incorrect valve clearance. Check the valve clearance.
10. Incorrect timing. Check the valve and ignition timing.
11. Water in carburetor. Remove the plug to drain off gasoline and water.
12. Cold oil. With the ignition switches off, turn the engine over by hand. If it is very stiff, it will be necessary to drain and heat the oil before starting.
13. Magneto breaker points. See that the magneto breaker points are clean and properly adjusted. Test the spark delivered by the magneto. The oil sump drain plug is equipped with a permanent magnet on the threaded end which is used as a means of trapping foreign particles in the oil sump. If some internal trouble is suspected, this drain plug should be removed and any trapped particles examined.

LOW OIL PRESSURE Low oil pressure or none at all may result from one or more of the following:

1. Lack of priming. Disconnect the oil suction line and fill the pump with oil. Turn the engine over by hand until the oil is sucked into the pump. Check the oil supply.
2. Leak in suction line. Examine the oil suction lines for air leaks.
3. Dirt in oil filter. Remove and clean the oil strainer.
4. Air lock or dirt on the seat of the relief valve. Removing and replacing relief valve will often free the oil for circulation.
5. Improper setting of relief valve. Adjust the oil pressure relief valve to obtain the value given on the engine data plate. If this pressure is not reached until the screw is all the way, or nearly all the way, down, the trouble lies somewhere else. Adjustment of the pressure should be made with the engine running and should be made when the oil is hot.
6. Excessive bearing clearance. A bearing may be worn enough to cut down the pressure, in which case an overhaul will be necessary.
7. High oil temperature. Excessive temperatures reduce viscosity of the oil, which then passes the bearings more freely and tends

to drop the oil pressure. Check the oil cooler shutters for opening and check the cooler for clogging.

8. Low outside temperature. In very cold weather the oil may become congealed in the suction line from the oil tank, preventing the oil from reaching the pump.

9. Foaming in oil supply tank. Foaming is a frequent cause of fluctuating oil pressure and loss of pressure. The presence of air in the scavenge oil is normal. The return oil from the engine should be directed into the supply tank in such a manner as to produce a minimum of splashing and to permit air which may be trapped in the return line to separate from the oil as readily as possible. If foaming is experienced, the oil should be removed from the system and replaced with fresh oil.

10. It should be remembered that the pressure will vary with the varying speeds and oil temperature, and due allowances should be made for the pressure drop to be expected at increased temperatures.

OIL ACCUMULATION IN CRANKCASE The filling of the crankcase with oil is usually caused by lack of priming in the scavenging pump. Disconnect the main discharge line from the engine and put on a short length of clean hose. While turning the engine backward, feed oil into this hose until a quart or liter or so has been sucked in. Check the oil pump, strainers, and lines for failure or stoppages.

Oil accumulation in the engine crankcase may also be due to high oil inlet temperature or pressure. Suggestions for determining the cause of excessive inlet temperature are listed below. If high pressure appears to be the cause of difficulty, the oil pressure relief valve setting should be checked and corrected if necessary.

EXCESSIVE OIL TEMPERATURE, HIGH OIL CONSUMPTION This condition may result from:

1. Insufficient oil cooling. The importance of an adequate blast over the oil tank cannot be overestimated.
2. Insufficient oil supply.
3. Low grade oil.
4. Suction pump failing to scavenge the oil properly from the crankcase.
5. Overheated bearing.
6. Dirty oil.
7. Worn piston rings.
8. Piston rings incorrectly installed.
9. Clogged oil lines, strainers, or coolers.
10. Improper venting of oil system.

LOW POWER AND UNEVEN RUNNING The rated speed of the engine will vary by 75 to 100 r.p.m. under different atmospheric conditions, the greatest variation occurring with the changing of the plane's angular position with regard to the wind when on the ground. It will also vary considerably with the condition of the propeller. The engine should not be considered low in power, therefore, unless the drop in speed is excessive under similar conditions.

Low power and uneven running may be traced to any of the following causes:

1. Rich or lean mixture. Too rich a mixture is evidenced by uneven running and black smoke from the exhaust. Too lean a mixture is evidenced by uneven running, overheating, and backfiring.

2. Leaks in induction system. Examine the intake pipes for cracks and for leaks at the cylinder and crankcase connections. Examine the carburetor and intake manifold flanges for tightness.

3. Spark plugs. See that all the spark plugs are clean, that they have the proper clearance, and that they are not burned. Test them for proper sparking and core leakage. Be sure that the spark plugs are in good condition and of the recommended type.

4. Valve and valve-gear trouble. Check the valve clearance, springs, washers, rocker arms, and push rods. Make sure the valves are not sticking.

5. Poor fuel. Use only the recommended grade of gasoline and see that it flows freely to the carburetor.

6. Magneto breaker points. See that the magneto breaker points are clean and properly adjusted. Check the operation of the magnetos.

7. Ignition wiring deteriorated or burned. Check wire condition, particularly at the spark plug terminals.

8. Engine overheating. This condition may be caused by items 1, 2, 3, and 5 above. It is easily recognized by the fact that the engine will run normally just after idling and will then slowly drop off in power. Continued running of an engine exhibiting this symptom is liable to cause considerable damage, so investigation of the cause should be started immediately. Other causes include improper cowling, excessive carburetor air temperature, thin oil, and insufficient oil cooling.
9. Ice on carburetor screen. Proper use of the air scoop will usually result in smoother operation of the engine.

LOSS OF POWER, STORMY WEATHER Loss of power due to clogging of the carburetor by atmospheric snow and ice during stormy weather may be attributed to the following:

1. Change in mixture ratio to rich or lean, depending on where the ice forms.
2. Decrease in venturi area due to ice formation.
3. Water lodging in the fuel passages causing the mixture to become extremely lean or the fuel flow to stop entirely.

To prevent or to correct trouble of this nature, use the air scoop which takes air from a region protected from atmospheric conditions, either behind the engines or elsewhere.

SPARK PLUGS When a spark plug is removed from an engine because of suspected trouble, it should be inspected thoroughly before disassembly. If the electrodes are heavily coated with carbon, the compression of the cylinder should be checked to determine whether the piston rings are worn or stuck and allowing oil to pass. The log book should be checked for evidence of high oil consumption. If the electrodes are clean but discolored and appear to have been running hot, this may be due to detonation from poor fuel, operating at incorrect manifold pressures, or a loose core. Core scale is an indication of overheating. Check the fuel, the cylinder temperatures, and see that the manifold pressure gauge is functioning properly. Check the spark plug core for tightness. If the electrodes are coated with a white powder, after operating with tetraethyl lead fuel, the plug may not have been firing and may have been overheated. Check the ignition wiring and spark plug terminals for failure. Check the magneto operation and the spark plug gap. A coating of fresh oil also indicates that the spark plug may not have been firing.

After the spark plug is disassembled, the core should be inspected for defects in the mica insulation. If the mica insulation is broken, flaked, or dented, or if any of the mica laminations project beyond adjacent laminations, the core should not be used.

MAGNETOS Trouble with burned magneto points may be traced in some instances to the application of excessive quantities of lubricant. If this is experienced, the magneto breaker assembly should be thoroughly cleaned and readjusted.

CARBURETOR LEAKAGE Because of the fire hazard, the engine should not be run if the carburetor leaks gasoline excessively.

Leakage of Bendix-Stromberg Injection carburetor may be caused by:

1. More than 4.5 lb. per sq. in. (.32 kg per sq. cm) pressure at the fuel inlet with the engine stopped.
2. Mixture control not in idle cut-off position.
3. Improper functioning of the discharge nozzle on the carburetor adapter.
4. Broken gaskets.

Leakage of a Holley or Chandler Evans carburetor:

Leakage of fuel from the ten .177 inch (4,49 mm) diameter nozzle bar holes when the carburetor is subjected to 6 lb. per sq. in. (0,42 kg per sq. cm) pressure with the throttles open indicates flooding of the diaphragm section which may be caused by:

1. Dirty or damaged fuel valve ball or seat.
2. Improper adjustment of the fuel valve operating levers.
3. Improper installation or damage to the fuel diaphragms.

Fuel leakage from the two elongated holes at the end of the nozzle bar adjacent to the throttle gears indicates:

1. Compensator needle is not seating properly.
2. Compensator spring is not installed.
3. Compensator seat is not screwed down tight on its gasket.

CHAPTER VII

PERIODIC INSPECTION ROUTINE

IN ORDER to obtain maximum reliability and service from engines, a regular schedule of inspections and overhauls should be maintained. Serious failures could possibly arise from minor causes which a few minutes inspection would have averted. The recommended inspection schedule is given in this chapter.

GENERAL One of the items of the various inspections is the checking of the tightness of miscellaneous nuts.

Experience has indicated that in a great many cases of bolt and stud failures on engines the cause of the failure has been excessive tightening of nuts. For this reason it is recommended that torque values be used on all threads listed in the Table of Limits. A number of torque indicating wrenches are available, some of which have a scale in inch-pounds, and some have an arbitrary scale which can easily be converted to inch-pounds or centimeter-kilograms. Each overhaul base and inspection base should have at least one wrench of this type on hand.

STARTING INSPECTION

Refer to Chapter on Starting and Normal Operation.

DAILY INSPECTION

1. See that the ignition terminals are secure. The terminal nuts should be only slightly more than finger tight.
2. Service the carburetor air cleaners at least once every fifteen hours of operation.
3. See that the throttle and mixture controls and the two-speed clutch control, if used, are free throughout their entire range.
4. Examine the exterior of the engine carefully for loose nuts, loose or leaking fuel and oil line connections, or other conditions which are abnormal.
5. Make certain the fuel and oil supplies are sufficient.
6. Inspect the cores of the oil coolers and fins of the cylinders to make sure that they are not plugged or coated with dirt. Cores and fins should be kept clean so that they will radiate the heat in an efficient manner.
7. Turn the Cuno oil filter handle daily or at least once every 10 hours of operation. If through occasional neglect the Cuno strainer handle is hard to turn, it should be turned back and forth by hand, first in one direction and then in the other until the cleaners free themselves and the handle can be turned through a complete revolution. Should it not be possible to free the strainer in the above manner or if the strainer handle is hard to turn, the assembly should be removed and thoroughly cleaned, using gasoline, kerosene, or a mixture of one part carbon tetrachloride and one part benzol. No wrench or other tool should be used to turn a strainer which has become clogged. The Wright Aeronautical Corporation will not be responsible for any damage to an engine which may result from the improper maintenance or neglect of the Cuno oil filter.
8. The engine should be rotated through two complete revolutions to make sure the engine is free from internal engine obstructions.
9. See that the engine operates well on either magneto.
10. Check the oil pressure, oil temperature, and gasoline pressure to see that the operation is normal. Guard against false oil pressure readings resulting from foam on the oil.
11. Open the blowout valve in the supercharger pressure gauge line at regular intervals. This valve should be opened for a period of ten or fifteen seconds with the engine idling.

FIFTY HOUR INSPECTION

In addition to the Daily Inspection the following items should be checked every fifty flying hours unless otherwise specified:

1. COMPRESSION Check compression of each cylinder, removing the front spark plugs from all cylinders except the one being tested. This should be done before the engine has thoroughly cooled after running. This item may be omitted on alternate inspection periods.

2. VALVE GEAR Remove the rocker box covers and check the valve rocker clearances. Reset any clearances which are not within the specifications. The engine should be cold when checking or setting these clearances.

3. IGNITION (a) Check the spark plugs for fouling and proper gap (.012 inch). Do not disassemble plugs unless absolutely necessary. Check center electrode for tightness. Reset the gap. When checking spark plugs for tightness between the shell and core, use wrenches designed for this purpose. Do not use excessive pressure.

(b) Check the magneto points.

(c) Check over the ignition wiring for defective insulation, using light or buzzer.

4. LUBRICATION SYSTEM (a) Drain the oil tank and fill with fresh oil.

(b) Remove the sump plug and screen for inspection and cleaning. Inspect magnetic plug for trapped particles.

(c) Clean oil cooler.

(d) Inspect all oil lines and fastenings.

(e) Inspect the lubricating felt attached to the magneto breaker cam followers. If this felt is soft and shows oil on the surface when squeezed between the fingers, no additional lubricant is needed. If this felt is dry, however, apply a small amount of oil to the portion of the felt attached to the cam follower main spring. Use just enough oil to make the felt soft and so oil can be brought to the surface by squeezing. Do not give it all it can hold. It is recommended that the best available grade of medium bodied engine lubricating oil be used. Lubricant of viscosity S.A.E. 30 is suitable for average conditions and S.A.E. 20 for cold weather operation. When possible, always choose a time for oiling when the engine and magneto are warm.

Never permit oil to reach the breaker contacts, as it would cause pitting, rapid wear, and interference with magneto operation. Keep the rest of the breaker mechanism clean and dry. Wipe the interior of the breaker housing clean before replacing cover, but do not permit lint or other foreign matter to lodge on the contacts.

The ball bearings are packed in grease and need no additional lubricant between overhauls.

(f) Remove the oil filter and clean the entire assembly.

(g) Inspect the tank oil system for traces of sludge or other foreign material. Accumulations of such material may become sufficient to impair oil cooling. The removal of such material is difficult because it is not soluble in gasoline or other commonly used flushing or cleaning solutions.

NOTE: **For cleaning and flushing the oil system, except in the engine, benzol is recommended. In order to reduce the fire hazard the benzol may be diluted, if desired, with as much as 50 percent carbon tetrachloride. After using this solution the oil system must be thoroughly dried out with compressed air.**

In using this material the oil system should first be drained completely, and then blown out. Use steam if it is available. Circulate the solvent for approximately 15 minutes with a hand pump. Drain the solvent from the system and blow out the lines. Dry the lines thoroughly with compressed air. Repeat these operations if necessary and make sure that all lines are thoroughly dried before refilling with fresh oil. It is recommended that the oil cooler be cleaned separately by removing it from the system.

If it is desirable to dilute the benzol and carbon tetrachloride is not available, a mixture of one-half 90 per cent benzol and one-half aviation gasoline may be used as a substitute. This mixture, however, is not recommended because it is highly explosive. In any case, extreme care must be taken to prevent fire.

The use of soap or water-mixed compounds in any form has been found injurious. The Wright Aeronautical Corporation will not be responsible for any damage to an engine which may be traced to the use of soap or caustic solutions, in any form, in the cleaning of oil systems.

(h) Inspect all oil lines and connections.

5. FUEL AND INDUCTION SYSTEM (a) Remove air screen and rinse in a pail of gasoline.

(b) Remove the carburetor fuel strainer and clean. Clean the external fuel strainer.

(c) Clean fuel tank sediment bulb.

(d) Check the fuel lines and connections to ascertain that they are secure and free from leaks.

(e) Check the carburetor for tightness.

(f) Check the air scoop for tightness.

(g) Check the intake pipe cap screws and packing nuts for tightness.

(h) Check the carburetor and scoop controls, and lubricate all joints and bearings.

(i) Check all drain lines for tightness and clear passages.

CAUTION: **Do not tighten the intake pipe packing nuts at the fifty hour check to remedy leaks, because such tightening may result in breaking the adhesive seal of the rubber packing. When the packing ring has once broken loose from the intake pipe or intake pipe boss, it will not adhere another time. Tightening packing nuts at the fifty hour check to remedy leaks may therefore result in increased leakage. Tightening packing nuts after no more than ten hours of operation on new rubber packing is permissible, because at this time the rubber packing is still soft and not adhered tightly to the nut. Leaking intake pipe packing is a fire hazard and a possible cause of improper mixture strength, and it is therefore recommended that the utmost caution be observed in following these recommendations.**

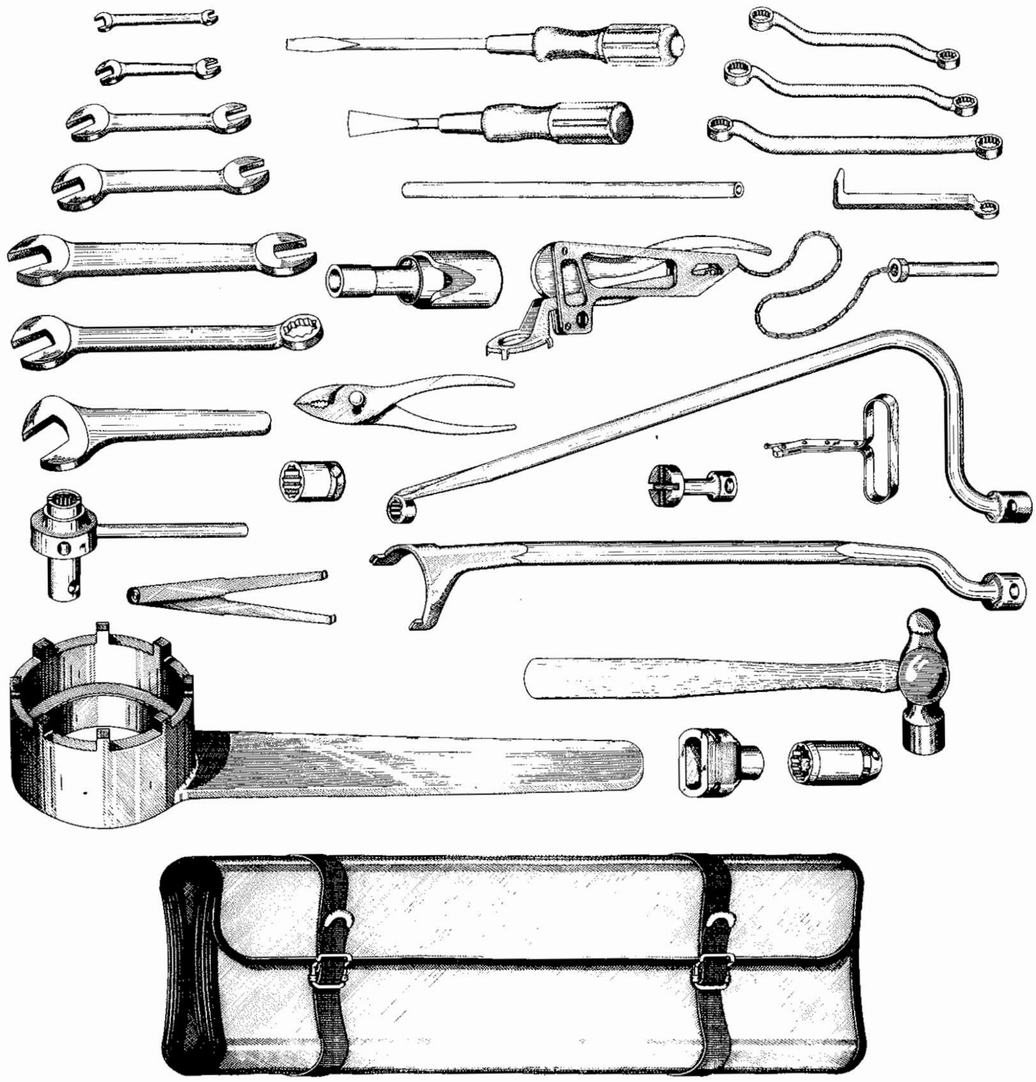
6. EXHAUST SYSTEM Check the exhaust pipes, exhaust manifold, and tail pipes for tightness and cracks. In order to reduce the possibility of difficulties arising from local overheating in the region of the exhaust port, care should be taken to draw up equally all exhaust flange stud attaching nuts. Exhaust leakage at this location caused by flange distortion or insecure fastening may result in burning of the exhaust port.

WARNING: **Care should be exercised to avoid pulling the exhaust flange attaching nuts too tight and stripping the studs from the exhaust elbows.**

7. EXTERNAL NUTS Check the following for tightness:

Accessory flange nuts
Tapped guide retaining nuts (Every 100 hours)
Engine mounting bolts
Cylinder flange cap screws (Every 100 hours)
Thrust bearing nut
Propeller hub nut
Exhaust flange stud nuts

MISCELLANEOUS Check the breather screen for cleanliness every 100 hours. It is advisable to run the engine at part throttle for a least one-quarter to one-half hour every 48 hours in order to keep the interior parts slushed with oil. This will prevent the vapor due to condensation in the crankcase from rusting steel parts.

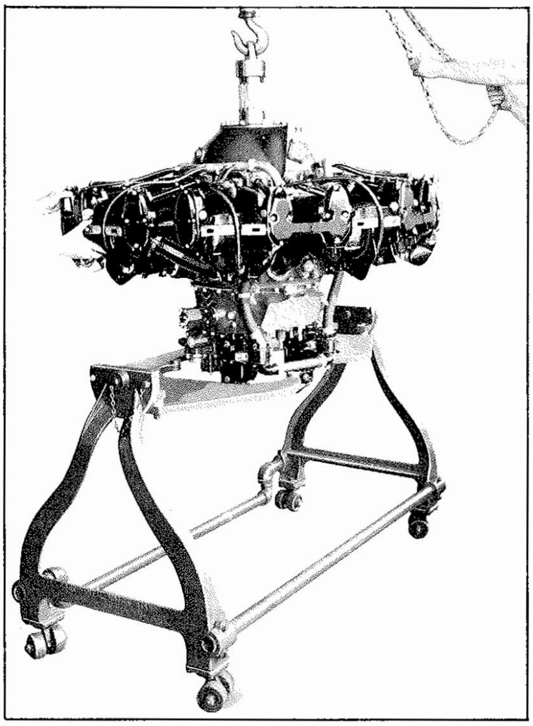


Representative Tool Kit

CHAPTER VIII

SERVICE MAINTENANCE

GENERAL The work outlined in this chapter consists of the service maintenance of the Wright C9-GC aircraft engine. The replacement of most of the parts may be accomplished with the tools supplied with the engine. Many of the procedures described will not necessitate an overhaul stand, but may be done while the engine is mounted in the aircraft. Complete overhaul is not within the scope of this book. The overhaul manual for the C9-GC engine may be obtained from the Wright Aeronautical Corporation.



Mounting Engine on Overhaul Stand

OVERHAUL STAND The best overhaul stand is the cradle type which permits rotating the engine to any desired angle. The mechanics are then able to do each part of the work with the engine in the most convenient position. If this type of stand is not available, the lower part of the engine shipping box may be used when it is desired to have the engine in the vertical position. The engine should be bolted firmly to the lower part of the shipping box before attempting to do any work. It will be assumed in this text that the rotating cradle type stand is available.

TOOLS A service tool kit is furnished by the manufacturer with each engine. This kit contains tools sufficient for the general servicing of the engine and should be carried in the airplane for use in emergencies.

CLEANING ENGINE PARTS Upon completion of the dismantling operations all separate parts and subassemblies should be washed with unleaded gasoline or other approved cleaning fluid before any further disassembly.

Experience has indicated that oil foaming and serious attendant difficulties may result from the use of water-mixed cleaning solutions, most of which contain either soap compounds or caustic soda. It has been found extremely difficult to remove all traces of these compounds from engine parts, and where compounds which contain soap are used, oil foaming may result immediately after starting the engine. In the case of the alkaline cleaners, the alkaline compounds combine with the oil in the presence of acids which come from combustion gases and are normally present in the oil and form soap which produces oil foaming. In this case, foaming may occur immediately or many hours after the engine is placed in service.

As a result of the above experience, the Wright Aeronautical Corporation recommends the use of unleaded gasoline, kerosene, or other hydrocarbons for cleaning purposes.

If water-mixed compounds containing any form of soap or caustic soda are used for clean-

ing, it is of the utmost importance that all parts or assemblies be thoroughly cleaned with clear boiling water after using the compounds. It is imperative that all traces of the cleaning compound be removed before the parts are assembled. It is recommended where these compounds are used that the parts be scrubbed thoroughly in clear boiling water and then rinsed in a separate bath of boiling water.

Engine parts may be cleaned with a 50-50 carbon tetrachloride-benzol mixture or clear gasoline-benzol mixture. However, these mixtures introduce difficulties in handling and extreme care must be exercised to prevent injury to the operator.

As washing of the various parts is completed, each part should be dried thoroughly with compressed air. If the parts are to remain unused for any length of time, slush them to prevent rusting.

Do not wash the accessories with any liquid solvents or cleaners unless it is stated in the publications of the respective manufacturer that it is permissible to do so.

SPARK PLUGS Remove spark plugs with the wrench designed for this purpose. Clean and reset the spark gaps to .012 inch.

CYLINDER AIR DEFLECTORS To accomplish cylinder assembly replacement it is necessary to remove cylinder head and cylinder barrel air deflectors. To remove the cylinder head air deflectors first remove the rear spark plug ignition lead from the channel in the deflector. Break the lock wire and remove the fillister head screw which secures the attaching flange at the cylinder intake port. Cut the lock wire from the fillister head screws at the top of the deflector and remove the screws. The cross member is slotted to permit easy access with a screw driver. In removing the cylinder barrel air deflectors it will first be necessary to remove the priming system tubes, if used, and the intake pipes in accordance with the removal instructions pertaining to the priming system, and to the intake pipes as described in this chapter. Remove the elastic stop nut and washer from the through bolt securing the cylinder barrel deflector and the barrel clamp. Remove the elastic stop nut and washers from the stud holding the deflector at the rocker box cover extension location. The rubber grommet and clamping plate should be temporarily bolted to the deflector stud to prevent loss. Remove the cylinder barrel air deflector from the rear. It will be unnecessary to remove the rubber packing unless replacement is required.

To remove the cylinder air deflector from the sump section, remove the nut, retaining plate, and grommet securing the deflector to the rocker box cover extensions. Break the lock wire and remove the two cap screws securing the deflector to each leg of the sump. Withdraw the deflector to the rear.

Install the cylinder barrel air deflectors by placing the air deflector in its approximate position between the cylinders. Place the air deflector clamp so that the edges of the channel-shaped clamp fit into the fifth and eleventh fin space, counting the space between the first and second fins from the crankcase end of the cylinder as No. 1. Install the through bolt loosely through the deflector, spacer, and clamp. Install a new elastic stop nut but do not tighten it at this time. Line up the deflector so that the stud protrudes through the space between the two rocker box cover extensions. Install the grommet and retaining plate, and secure with a new elastic stop nut. Tighten the air deflector clamp at the base of the air deflector.

To install the air deflector at the sump location, place the deflector in its approximate position. Install the two cap screws and washers loosely, securing the deflector to the two legs of the sump. Line up the stud with the space between the two rocker box cover extensions, install the rubber grommet and retaining plate, and secure the assembly with a new elastic stop nut. Tighten the cap screws and the sump legs and lockwire securely.

PRIMING SYSTEM If a priming system is used, detach the supply line from the distributor. Unscrew the priming tube union nuts from the connections on the intake ports and at the distributor nipples. If the same tubes are to be installed, tag or otherwise mark each priming tube to indicate to which cylinder it is attached. Remove the nut, washers, and bolts securing the priming tube clamps to the intake pipes. Spread open the clamps to remove the priming system tubes. It will be unnecessary to remove the distributor from the No. 1 cylinder intake pipe if this unit does not require replacement. Exercise extreme care in removing the priming tubes to prevent bending. A bent tube will present great difficulty at in-

stallation and may restrict the flow of the priming charge in the tube.

If removed, attach the distributor to the clamp and place the clamp on the No. 1 cylinder on the intake pipe at the approximate mid-position facing the rear. Do not tighten the clamp at this time. Place each priming tube in its approximate location and slip the clamps over the intake pipes. Install the nuts and bolts but do not tighten. Screw on the union nuts at the intake ports and at the distributor. Tighten each union nut at the intake port and distributor location. Tighten all the clamp nuts.

INTAKE PIPES If a priming system is used, it will first be necessary to remove priming tubes before the removal of the intake pipes. Loosen the packing nuts at the crankcase end of the intake pipe. This may be done with a special crowfoot type wrench which fits the castellations on the nut snugly. Remove the three cap screws at the flange end of the intake pipe. Remove the washers and pull the flange back from the intake port. Discard the gasket. Withdraw the intake pipe from the supercharger front housing and remove and discard the intake pipe flange packing. Remove the packing nut and packing from the supercharger front housing. Discard the packing.

Install a new packing ring in the supercharger front housing port and loosely install the packing nut. Place a new packing ring at the cylinder end of the intake pipe beneath the attaching flange. Coat the crankcase end of the intake pipe with clean engine lubricating oil and insert into the supercharger front housing. Install a new gasket between the intake pipe attaching flange and the intake port parting surface and install the three cap screws making sure a shake-proof washer is installed under the head of each cap screw. Tighten the cap screws evenly, and lockwire securely. Tighten the packing nut at the crankcase end of the intake pipe, using the crowfoot type wrench and handle.

SEALING COMPOUND It is recommended that a sealing compound (Scintilla Sealing Compound No. 47 — W.A.C. 115963N1) be used to fill the air space around the cable in the spark plug elbows, spark plug terminal wells, and magneto terminal wells. The compound is a non-hardening, semi-solid compound and is tested to insure its consistency and insulating qualities.

The following instructions cover specific applications:

SPARK PLUG WELLS Hold the terminal securing nut back and apply a thin coat of the compound on the outside surface of the insulating sleeve. Also fill the contact spring secured to the insulating sleeve with the compound. Push the insulating sleeve into the spark plug well until the ridge at the end of the elbow rests in position on top of the spark plug barrel. Since the compound is an insulator, remove any excess which may be forced out at the top of the spark plug barrel with a clean lintless cloth.

Ensure that the excess compound is wiped off clean to prevent its being forced into the threaded portions of the terminal nut and spark plug or past the shoulder on the elbow thus insuring that the required metallic bond is not broken. After the excess compound is wiped off, tighten the terminal nut.

SPARK PLUG ELBOWS Spark plug elbows may be filled by use of an alemite type pressure gun with a suitable adapter to fit the terminal nut.

Remove the spark plug terminal sleeve from the ignition cable. Insert the end of the ignition cable into the adapter of the pressure gun and screw the spark plug terminal nut down tight on the adapter. Inject the sealing compound into the spark plug elbow by means of the pressure gun.

NOTE: **Care must be taken to prevent the compound from forcing the ignition cable back into the spark plug elbows. After filling the spark plug elbow, remove the pressure gun and wipe off any excess compound on the ignition cable with a clean lintless cloth. Install the spark plug terminal sleeve in the usual manner.**

MAGNETO BLOCK TERMINAL WELLS Apply a thin coating of compound on the outside surface of each ignition cable for a distance equivalent to the depths of the respective wells in the distributor block. Push the ignition cables into the proper terminal wells and secure with piercing screws in the usual manner. Remove any excess compound with a clean lintless cloth.

NOTE: **Since the compound has an adhesive quality, care must be taken that the coated surfaces are kept clean of foreign particles and dirt before installing the terminals.**

IGNITION HARNESS To remove the ignition harness proceed as follows: Disconnect the spark plug terminals from the front and rear spark plugs. Remove the clamps securing the harness leads to the push rod housings and withdraw the ignition leads from the channel sections in the cylinder head air deflector. If the extended type rocker box covers are used, it will be necessary to remove these covers from rocker boxes number 1-exhaust, number 1-intake, number 2-exhaust, number 9-intake. If the non-extended type is used, the covers need not be removed. Remove the priming system as previously described. Remove the cylinder barrel air deflectors from between cylinders number 1 and 2, and number 1 and 9. Remove the intake pipe to cylinders number 1 and 9. Remove the four clamps securing the harness to the supports which are bolted to the crankcase front section at the housing parting surface location. Remove the two cap screws securing the top section and the radio shielding to each magneto. Remove the six cap screws from each magneto which secure the coil cover and distributor block housing. Remove the two halves of each distributor block housing after removing the nuts and bolts at the top of the housings.

Pull the section of radio shielding extending between the two magnetos straight up and disengage the two magneto blocks from the magneto housings. Remove the ignition wire harness complete with the magneto blocks from the engine, by lifting it upward to clear the cylinders. If any part of the ignition harness is damaged, the part may be removed from the harness assembly by loosening either one or more of its adjacent knurled couplings and replacing with a new part.

To replace an ignition wire, strip the insulation from the magneto end of the ignition cable to be replaced so that approximately one inch of the wire is bared. Bare likewise the same length of wire at one end of the new cable to be installed. Be careful not to cut any wire strands when removing the insulation. Attach the new cable to the cable requiring replacement by tying a neat, tight square knot in the two wires. To prevent damage to other cables when the new cable is pulled into the manifold assembly, it is important that this joint be carefully made. Draw the new cable into the manifold assembly by pulling on the spark plug end of the old cable. This may be more easily accomplished if two men work together, one pulling slowly on the old cable and the other feeding the new cable into the main conduit at the magneto end. Use as little force as possible in pulling the cable, since excessive tension greatly decreases the insulating properties of the rubber. To facilitate the pulling of the new cable into the manifold assembly, the new cable may be lightly coated with talc or powdered mica. No other anti-friction agent should be used for this purpose.

When the new cable has been drawn through the manifold assembly far enough to permit reassembly of the wiring harness, cut the old cable from the new, and cut the new cable to the correct length. Prior to installing one end of the cable in the distributor block, bare approximately one-half inch of the cable, spread the strands of wire, and fold them back over the insulation. Install a copper ferrule over the cable and secure it in place using a swedging tool. Insert sealing compound as previously described. Reinstall the shielded spark plug conduit, replacing the used rubber washer with a new washer.

If the spark plug terminal is replaced or reinstalled, the following procedure should be used: Straighten out the ignition cable strands which are fanned out at the base of the coiled contact spring and pull the spring and sleeve assembly from the ends of the cable. Loosen the knurled coupling securing the terminal elbow to the spark plug conduit, and withdraw the elbow and rubber packing gland.

To replace the spark plug terminal, install the spark plug elbow, using a new rubber packing gland, and insert sealing compound. Make sure the contact spring and washer assembly is not loose in the sleeve of the replacement terminal. Twist the ends of the ignition cable slightly and insert the cable in the contact sleeve. The stripped end of the cable should protrude through the hole in the washers at the base of the contact spring about one-eighth inch. Fan the strands of the cable around the washer and press the strands securely into position over the end of the contact washer nipple by means of a short copper tube (one-eighth inch in diameter). Ensure that the terminal sleeve fits snugly into the recess in the terminal elbow and tighten the knurled coupling nut securing the terminal assembly to the radio shield.

Install the ignition harness by placing it in its approximate position on the engine. Insert the magneto distributor block in its recess in the magneto housing, using extreme care not to

damage the contact buttons. Install the two halves of the distributor block housing and clamp them together with screws, lock washers, and nuts. Place the magneto coil cover in its position on the magneto and secure both the distributor block housing and the coil cover with the six slotted head cap screws, using a new lock washer under the head of each cap screw. Install the four clamps securing the two halves of the ignition harness to the four supports which are bolted to the crankcase front section. Attach the flexible radio shielded ignition leads to the push rod housings by means of the clamps, and secure the ignition leads for the front and rear of each cylinder together by means of clamps to prevent vibration of the leads. Install the cylinder barrel air deflectors, intake pipes, and priming tubes as previously described. Place the rear ignition leads in their respective locations in the channel sections of the cylinder head air deflectors and attach the terminals to the spark plugs. Attach the front spark plug terminals to their respective spark plugs.

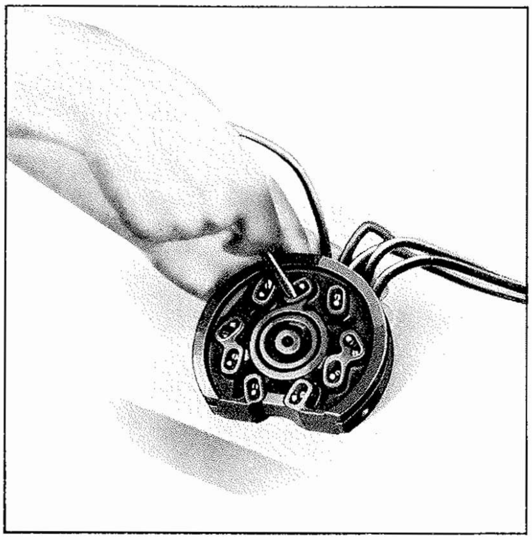
MAGNETO DISTRIBUTOR BLOCK To separate the magneto block from the ignition cable, observe the following: Remove the six cap screws securing the coil cover and distributor block housing to the magneto and remove the coil cover. Remove the two slotted cap screws from each side of the magneto distributor block housing and the two nuts and bolts at the top of the housing. The housing may be separated and removed from the magneto block. Remove the cable piercing screws adjacent to the electrodes in the distributor block and withdraw the ignition cables. Remove the booster cable, if provided, by removing its piercing screws. The block may now be separated from the ignition cable assembly.

To assemble the magneto distributor block to the ignition cables, proceed as follows: Insert the cables through the radio shielding if the shielding was removed. Insert the cables through the ignition wiring harness attaching flange at the top of the magneto if removed. A copper ferrule is swedged over the end of the ignition cable which is inserted in the magneto block. The cable strands are folded back under the ferrule to ensure good contact and each ferrule is stamped with its distributor block number. Use sealing compound and insert each ignition cable in its corresponding hole in the distributor block as denoted by the numbers on the ferrule and the magneto block. The numbers on the magneto denote the serial firing order of the magneto and not the cylinder numbers. Make sure that the cables bottom in the holes in the distributor block, and screw down each cable piercing screw to ensure security and proper contact. No lock washers are employed under the cable piercing screws.

If a booster magneto cable is used, insert its end in the distributor cable hole marked "B" and secure it with the cable piercing screw. If no booster wire is installed, be sure that a lock washer is placed under the head of the cable piercing screw.

Install the two halves of the distributor housing and secure with the slotted head screws and the nuts and bolts at the top of the housing. Tighten all the remaining screws retaining the housing assembly.

Before installing the ignition shielding assembly, check the ignition wiring for shorts or open circuits and to ascertain whether the ignition cables lead to the proper cylinders from the magnetos. To test for a short circuit due to faulty insulation of the cable, a booster magneto should be used. Connect the high tension terminal of the booster magneto to a distributor block electrode and hold the spark plug end of the corresponding ignition cable about ⅜ inch from a suitable ground. If a good spark does not jump the gap, examine the cable for faulty insulation. To test for an open circuit in the cable and to check the firing order of the cylinders, a buzzer or light system should be used.



Attaching Wire in Distributor Block

The following table gives the relation between the cylinder and magneto fire order:

Magneto Distributor Block	Cylinder Number
1	1
2	3
3	5
4	7
5	9
6	2
7	4
8	6
9	8
P	Magneto Ground
B	Booster Magneto

Tighten all knurled, shielding coupling nuts and cap screws.

MAGNETOS To replace a magneto proceed as follows: Remove the magneto air blast tube, if used, and remove the coil cover and distributor block in accordance with instructions previously described. Remove the magneto ground terminal by loosening the knurled coupling joining the radio shield and ground wire to the "Y" junction. Loosen the knurled coupling joining the radio shielded ground wire which inter-connects the two magneto ground junctions. Remove the lock wire from the castellations on the ground terminal retaining nut and withdraw the magneto ground terminal assembly complete. Remove the breaker housing cover which exposes the cam and pivotless contact breakers in the housing.

With the ignition switch OFF and the mixture control set at IDLE CUT-OFF turn the engine crankshaft in the direction of normal rotation, until the step cut in the breaker cam lines up with the timing mark cut in the rim of the breaker cup. Use a straight edge to line up marks. At this point the timing mark on the distributor rotor will coincide with the mark on the magneto front end plate indicating that the rotor is in a position to distribute a spark to No. 1 cylinder.

If the timing hole plug in the crankcase front section is available, check to ascertain whether the reading on the scale on the reduction driving gear is in agreement with the value given on the engine data plate.

The following procedure is recommended in removing a magneto in the event that the timing hole plug in the crankcase front section is not accessible: Insert a piece of .001 inch steel feeler stock between the contact points by lifting the felt cover cam follower which causes the points to open. If the breaker spring itself is lifted to insert the feeler between the points, a permanent set may result from excessive bending. If the points have already begun to open, insert the feeler stock and turn the engine crankshaft slightly in the direction opposite normal rotation or continue turning in the normal direction of rotation until the breaker points are closed, with the felt-lined follower resting on the flat of the cam preceding the lobe which opens the breaker points to furnish No. 1 cylinder with its firing spark. Now turn the engine slowly in the direction of normal rotation and pull lightly on the feeler stock. Stop turning the crankshaft at the instant the feeler stock starts to slip, indicating that the breaker points are opening.

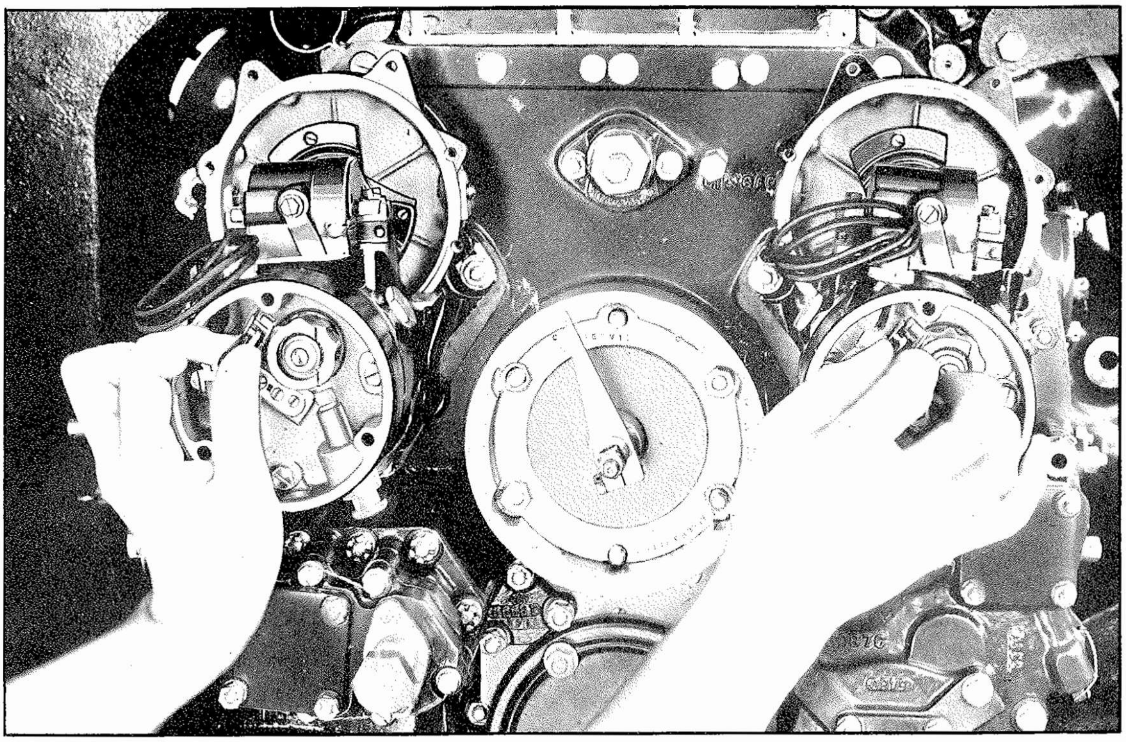
CAUTION: **Do not disturb the engine crankshaft setting thus obtained until the magneto has been reinstalled.**

Remove the cotter pins, castellated nuts, and washers from each of the three attaching studs, holding the magneto to keep it from dropping due to its overhanging construction. Remove the magneto.

Before installing the magneto, first check the adjustment of the breaker contact as follows: Lift the cam follower and wipe the contact points with a clean cloth moistened with unleaded gasoline. Do not allow gasoline to come in contact with the felt covered follower as this would thin the oil in it. Line the magneto timing marks as described previously. If the timing marks do not coincide with the step cut in the breaker cam, turn the magneto shaft until the alignment is made, keeping the .001 inch feeler stock between the points. Loosen the two screws which fasten the breaker assembly to the breaker housing. Hold the magneto shaft in the aligned position and adjust the eccentric so that the contact points are just beginning to open. Tighten the retaining screws and recheck the adjustment.

With the adjustment thus obtained the magneto is set to deliver a high-tension spark to the number 1 cylinder spark plug.

If the timing plug on the left side of the crankcase front section is accessible, break the safety wire and remove the plug with its copper-asbestos gasket. If the crankshaft has not been disturbed since the magneto was removed, following the procedure previously described, the number of degrees indicated on the timing scale should equal the spark timing value on



Timing the Magneto

the engine data plate. Check to see that these values are equal, and if not, turn the propeller shaft to make the values correspond. In the event that the timing plug hole in the crankcase front section is not accessible, the crankshaft setting obtained prior to the magneto removal should be used for reinstalling the magneto.

Apply a heavy grade of petrolatum to the splines of the magneto drive shaft coupling. With the distributor rotor held in the position to fire No. 1 cylinder, install the magneto on the supercharger housing rear cover. Having the splined magneto coupling inserted into the mating splined end of the engine magneto drive gear, move the magneto to its extreme positions allowed by the slots in the mounting flange, noting if the breaker points open and close. If the breaker points open and close, assemble a flat washer and a castellated nut on each of the three attaching studs sufficiently tight to hold the magneto firmly on the cover, but not tight enough to prevent adjusting the position of the magneto.

If the points do not open and close when moving the magneto from side to side, withdraw it from the engine. Install the magneto coupling wrench over the splined drive shaft coupling to keep the shaft stationary, and remove the cotter pins, castellated nut, and washers which retain the coupling on the shaft. The coupling, which is fitted to the shaft by six slots on its inside diameter, should be withdrawn, turned to the next slot engaging position, and reinstalled on the shaft. Install the retaining washers and nut and check the opening and closing of breaker points with the magneto on the engine. When the results are satisfactory, withdraw the magneto to install the cotter pin in the coupling retaining nut, and reinstall the magneto on the engine. All adjustments must be made at the drive end of the magneto by changing the location of the coupling splines and not by altering the breaker points opening adjustment.

Move the magneto in the direction opposite to crankshaft rotation until the breaker points open and insert a strip of .001 inch steel feeler stock between them. Move the magneto as far as it will go in the direction of crankshaft rotation so that the breaker points have closed on the feeler stock. Tap the magneto slowly back in the other direction and pull lightly on the feeler stock until it starts to slip, indicating that the breaker points are just beginning to open. Tighten the three flange attaching nuts to secure the magneto at this location.

Check the setting by turning the propeller

backward about a quarter of a revolution and reinstalling the strip of .001 inch feeler stock between the breaker points. Tap the propeller forward slowly, stopping when the feeler strip is released from the breaker points. The crank angle degrees reading observed on the rim of the reduction driving gear through the crankcase front section timing plug should correspond to the engine data plate spark advance at the instant the feeler strip is released. Install the cotter pins in the magneto flange attaching nut when the correct spark advance setting has been established.

Install the plug in the timing inspection hole in the crankcase front section with the copper-asbestos gasket under its head. Tighten and lockwire.

Install the breaker housing cover and tighten the two hex-head cap screws which are retained in the cover by circlets. Check the cap screws for a lock washer under the head of each.

Reinstall the distributor block, coil cover, radio shielding, and ground terminal as previously described in this Chapter.

CARBURETOR AIR SCOOP, CARBURETOR, AND ADAPTER For maintenance, servicing, and repairing of the carburetor consult the manufacturer's publications. To remove the carburetor, disconnect the throttle and mixture controls and remove all lines to connections in the carburetor and adapter. Remove all lines and heater controls from the air scoop. Remove the palnuts, nuts, and washers securing the air scoop to the carburetor and remove the air scoop, air screen, and gaskets. Remove the cotter pins, nuts, and spherical seat washers securing the carburetor to the supercharger rear housing. Remove the carburetor and gasket.

NOTE: **Cover the opening into the induction chamber with a suitable cover or plate to prevent the entrance of foreign material into the induction chamber.**

Before installing the carburetor, prepare it for service in accordance with the instructions given in the manufacturer's publications.

Remove the cover plate from the mounting pad on the supercharger rear housing. Install a new gasket over the mounting studs. Place the carburetor in position over the mounting studs and install the spherical seat washers. Install the nuts, drawing them up snugly against the washers. Tighten all the nuts evenly, lining up the cotter pin holes, and cotterpin securely. Place a new gasket over the air scoop mounting studs and install the screen. Using new gaskets, reassemble the screen and air scoop. Secure the air scoop with plain washers, nuts, and palnuts. Connect the throttle, mixture, and heater controls and all other connections to the carburetor, adapter, and air scoop.

Check all controls for ease of operation and full travel.

OIL PUMP AND TACHOMETER Unscrew the temperature bulbs from the inlet and outlet chambers of the oil pump. Remove the oil inlet and oil outlet lines and remove the tachometer connections. Break the safety wire and remove the special shouldered cap screw from the attaching leg at the right of the oil pump. Break the safety wire and remove the nuts and washers from the eight long attaching studs and remove the pump. Support the pump to prevent separation of the covers and housings. Retain the housings and covers by installing two long bolts of the same diameter as the mount studs.

When installing the oil pump, place a new gasket over the long oil pump attaching studs, making sure the oil holes line up correctly. Coat the oil pump drive shaft coupling with a good grade of heavy petrolatum and install the pump over the attaching studs, meshing the coupling with the splined end of the drive shaft in the supercharger rear housing cover. Install the plain washers and castellated nuts on the attaching studs. Tighten and safety-wire the nuts together. Place a plain washer under the head of the special shouldered cap screw which secures the attaching leg of the oil pump to the supercharger rear housing cover. Lockwire the cap screw. Reinstall the tachometer cables, oil lines, and temperature bulbs on the pump.

OIL PRESSURE RELIEF VALVE To adjust the oil pressure relief valve to attain the desired pressure, break the lock wire and remove the steel cap and gasket from the oil pressure relief valve assembly, located on the rear of the oil pump adjacent to the end plate. Loosen the large lock nut on the slotted adjusting screw to permit movement of the screw in either direction. Screwing in the clockwise direction increases the relief valve spring tension and engine oil pressure, and the opposite result is obtained by the counter-clockwise movement of the adjusting screw. When the desired engine oil pressure has been obtained, tighten the lock nut

against its shouldered copper gasket. Reinstall the steel cap and its shouldered copper gasket, and lockwire the cap.

To disassemble the oil pressure relief valve, break the lock wire and remove the oil pressure relief valve steel cap and lock nut with their shouldered copper gaskets. Unscrew the slotted adjusting screw all the way off the bronze relief valve body, being careful not to lose accidentally the coiled spring which is immediately behind the adjusting screw. Remove this coiled spring and withdraw the steel piston from the bore of the relief valve body.

To assemble the oil pressure relief valve, lubricate the hollow piston type valve with engine oil and insert it into the bronze relief valve body and place the coiled spring inside the piston. Screw the adjusting screw in approximately one-half of its length on the outside diameter of the bronze body over the extended end of the coiled spring. Install the lock nut and its shouldered copper gasket on the adjusting screw. Tighten the lock nut, and install the steel cap and its gasket. Lockwire the cap. Final adjustment of the pressure relief valve is made while the engine is running.

OIL PUMP CHECK VALVE Break the safety wire and remove the cadmium plated retainer from the left side of the oil pump. Remove the copper asbestos gasket, spring, and hollow piston from the bore of the bronze valve body. The valve body is pressed into the oil pump body and cannot be removed in the field. The steel piston employs one piston ring and may be replaced without the use of special tools. Expand the ring slightly and slide it over the chamfered end of the piston dome and into the piston ring groove.

Assembly is accomplished by lubricating the piston and ring assembly and inserting it into the bronze check valve body, compressing the ring to permit entrance. Insert the spring into the hollow piston, and screw on the retainer, having a new gasket under the flange. Tighten and lockwire the retainer to prevent its loosening.

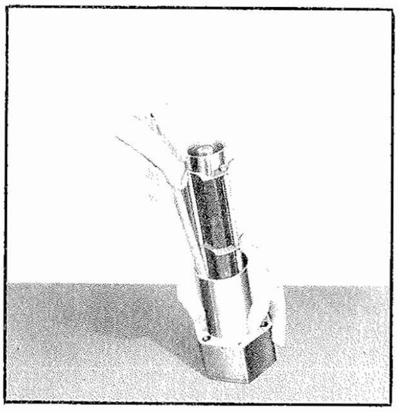
CUNO AUTOMATIC FILTER The Cuno automatic filter is attached to the left side of the supercharger rear housing slightly below its midsection.

The removal of the filter is accomplished by breaking the lock wire and removing the three-shouldered attaching cap screws. It may be necessary to tap the filter lightly with a rawhide mallet to effect removal if the filter is stuck. Removing the extended cap nut on the outer face of the filter head exposes a pinion shaft which is provided to turn the filter manually for test or inspection purposes. Reverse the cap nut and screw it on the end of the pinion shaft thus providing a means of turning the filter.

Reinstall the cap nut in its original position on the pinion shaft bushing, and lockwire. Insert the filter in its recess in the supercharger rear housing, with its inner end fitting snugly in the supporting boss at the center of the supercharger rear housing cover. Make sure a new gasket is installed under the head of the filter. Insert the three remaining cap screws, tighten, and lockwire together.

SUPERCHARGER DRAIN VALVE Standard Type: Disconnect the drain line from the outlet connection on the supercharger drain valve, located on the lower right side of the supercharger rear housing. Remove the drain valve assembly by unscrewing the steel body out of the shouldered bronze bushing in the supercharger rear housing. This steel body is provided with hexagonal flats on its shank to accommodate an open end wrench.

To install the standard type drain valve, insert the drain tube into its passage where it is retained by screwing the steel body into the shouldered bronze bushing, using the hex flats milled in the shank of the body. Swing the aluminum alloy drain valve housing into the desired position for attaching the drain line, and secure it by tightening and lockwiring the drain valve retaining plug. Connect the drain line to the outlet nipple in the drain valve housing.



Cuno Oil Filter

SUPERCHARGER OIL SEAL VENT At the forward end of the supercharger rear housing, adjacent to the carburetor adapter, is located the supercharger oil seal vent breather. This fitting consists of a hollow hex head steel plug having breather holes drilled under the head and a fine mesh brass screen over the bottom of the pipe-threaded shank. Outwardly it resembles a large cap bolt screwed part of its length into the supercharger rear housing.

This vent fitting may be removed from the supercharger housing for cleaning or replacement. When reinstalling, care should be taken not to clog the fine brass screen on the inner end.

DUAL ACCESSORY DRIVE ASSEMBLY Ensure that the dual accessory drive housing is accessible by removing all lines from the accessories driven by that unit. Remove the palnuts, nuts, and washers from the attaching studs on each of the two mounting pads and withdraw the accessory or cover plates with their gaskets. Remove the loose fitting tongue drive adapter where utilized in the splined drive shaft. Break the lock wire and remove the special cap nuts and washers from the two studs extending from the supercharger rear housing cover through the upper left side of the dual accessory drive housing. Remove the palnut, nut, and washer from the one remaining attaching stud on the right side of the cover adjacent to the lower drive mounting pad.

Remove the dual accessory drive cover and gasket by tapping on its sides with a rawhide mallet, being careful that the spur gears remain in their bushings in the housing. Withdraw the upper and lower gears, after which the two intermediate gears may be removed, exposing the nuts holding the dual accessory drive housing to the supercharger rear housing cover.

Remove the castellated nuts and washers from the two studs extending from the supercharger rear housing cover through the central portion of the accessory drive housing wall section. Break the lock wire and remove the shouldered nuts and washers, located at the corners of the housing, using an offset box-socket wrench and handle. Remove the acorn nuts and copper washers from the studs which extend from the bottom of the accessory drive housing through the supercharger rear housing and cover parting flanges. Remove the dual accessory drive housing and gasket from the supercharger rear housing cover by tapping with a rawhide mallet.

When installing the dual accessory drive prepare the supercharger rear housing cover to receive the drive unit as follows: Remove the two pipe plugs from the lower left corner of the dual accessory drive mounting pad on the supercharger rear housing cover, thus uncovering holes for lubrication oil from dual accessory drive gears to drain into the supercharger rear housing. Remove the two flat head bolts extending through the lower right corner of the dual accessory drive mounting pad. Remove the palnuts and nuts from the two supercharger rear housing cover attaching studs immediately above the countersunk flat head bolt holes and from the adjacent attaching stud at the left of the countersunk holes. Remove the palnuts and nuts from the four studs holding the cover plate over the spare accessory drive shaft and withdraw the cover plate and drive gasket. Place a dual accessory drive mounting pad gasket over the studs now exposed. Make sure that the pipe plug has been removed from the tapped drain hole in the lower corner of the dual accessory drive housing. Place the housing in position on its attaching studs but do not push it all the way on to its mounting pad until the nuts are started on the studs under the over-hanging parting flange. The three supercharger rear housing cover attaching studs at the outer corner of the accessory drive housing utilize plain washers and special shouldered nuts requiring the use of an offset box socket wrench and handle. The two studs extending from the supercharger rear housing cover through the central part of the accessory drive housing employ plain washers and castellated nuts. The castellated nut in the center of the housing is cotterpinned and the other four nuts are lockwired. Install copper washers and acorn nuts on the two studs which extend from the bottom of the accessory drive housing through the countersunk holes in the supercharger rear housing cover, and lockwire the drilled tips of the acorn nuts together.

Oil the four bushings in the accessory drive housing with engine oil. Place the primary drive gear (large teeth) in mesh with its intermediate gear and insert the two gears together into their supporting bushings in the accessory drive housing. The upper and lower accessory drive gears may then be placed in the housing, taking care to have the gear with involute splines and short front journal in the upper blind bushing and the gear with square splines and long front journal in the lower open bushings. Timing marks

are not necessary on any of the spur gears making up the dual accessory drive.

Install a gasket on the dual accessory drive housing parting surface and coat the gears with engine oil. Place the cover on its attaching studs and slide it forward over the rear journals of the gears. Place a plain washer and special cap nut on each of the two studs extending from the supercharger rear cover through the upper left side of the accessory drive housing. Similarly, install a plain washer and plain nut on the cover attaching stud located between the upper and lower drives. Tighten these nuts evenly, lockwiring the two special nuts together, and install a palnut over a plain nut. Install gaskets and accessories or cover plates on the two mounting pads. Secure the accessories or cover plates with plain washers, nuts, and palnuts.

OIL SUMP Remove the No. 5 cylinder intake pipe and the cylinder air deflectors as previously described. Break the lock wire, and remove the magnetic drain plug and gasket from the bottom of the sump. Drain the oil into a clean receptacle, strain, and examine carefully for foreign material, if desired. Reinstall the plug loosely to prevent loss. Remove the three palnuts, nuts, and washers securing the front attaching flange of the sump to the crankcase front section. Support the sump and remove the two palnuts, nuts, and washers which secure both arms of the sump to the supercharger front housing. Withdraw the sump. Remove the strainer and magnetic plug, and clean with unleaded fuel.

To install the oil sump, place new gaskets at the mounting flange locations. Make sure that the oil holes line up perfectly with the holes in the sump. Place the sump in its proper position and install the washers and nuts. Tighten all nuts evenly to the proper torque value as indicated in the Table of Limits. Install palnuts on each of the studs and tighten. Reinstall the screen and magnetic drain plugs, if removed, using new gaskets under each. Lockwire the plugs securely together. Reinstall the air deflectors and intake pipe.

PUSH RODS AND VALVE TAPPETS The following procedure is given for cases in which it is desired to remove a push rod without removing the rocker arm hub bolt or disturbing the torque setting which has previously been applied to the rocker bolt nut.

Remove the clips securing the ignition leads to the push rod housing. It will be unnecessary to remove the clips from the leads. Loosen the two hose connection clamps at the crankcase end of the push rod housing and the single hose clamp at the cylinder end of the housing. Slide the crankcase and hose connection along the push rod housing until the bead on the end of the housing is visible.

Remove the nuts, lock washers, and plain washers from the four rocker box cover attaching studs of the rocker box from which the push rod is being removed and remove the cover. Loosen the adjusting screw lock screw in the rocker arm and screw the adjusting screw all the way out to its stop. Screw the push rod removing tool on the extended threads of the valve clearance adjusting screw and insert the handle to serve as a lever and compress the valve springs. The push rod, housing, and hose connection may be removed as a unit through the slot in the tappet guide.

If the special push rod removing tool is not available, it will be necessary to remove the rocker arm before the push rod can be withdrawn. In this case, remove the rocker box cover. Remove the cotter pin from the rocker bolt nut and remove the nut. Turn the crankshaft so that the valve is seated and a clearance exists between the rocker roller and the valve stem. Push or drive out the rocker bolt, being careful not to damage bolt threads, and remove the spherical seat washer from each end. Lift out the rocker arm and the push rod, and remove the push rod housing by loosening the clamps and sliding the crankcase end connections along the housing.

Remove the loose fitting valve tappet ball socket and spring from the tappet, turning the crankshaft, if necessary, to bring the tappet into reach. Remove the palnuts, nuts, and washers from the two tappet guide attaching studs and withdraw the tappet and guide assembly from the crankcase front section. If the guide cannot be removed by hand, attach the tappet guide puller. Remove the gasket under the guide flange.

The tappet and guide assembly may be separated by inserting the hooked end of the valve tappet circlet removing tool under the retaining circlet to effect its removal. DO NOT ATTEMPT TO MAKE THE CIRCLET JUMP OUT OF ITS GROOVE BY STRIKING THE HOLLOW END OF THE TAPPET WITH A DRIFT. Care should be taken to avoid loss of any of the parts during this

operation as the floating tappet roller, bushing, and pin are exposed when the retaining circlet is removed. The tappet may be separated from its guide and complete disassembly of the roller and bushing effected by pushing the floating pin out of the slotted end of the tappet.

At installation, place the tappet roller equipped with its floating bronze supporting bushing in the slotted end of the tappet and insert the floating pin. Slide the tappet and roller into the tappet guide and install the retaining circlet using the installing tool. Install a new gasket under the tappet guide flange and insert in the crankcase front section. Install a plain washer, nut, and palnut on each of the two attaching studs. Insert the coiled spring and ball socket in the tappet. Ensure that all engine parts are thoroughly coated with engine oil before assembly.

Install a new short hose connection and one clamp on the rocker box end of the push rod housing. This end of the push rod housing may be identified by the location of the beading which is approximately 3/8 inch from the end. Install a new long hose connection and two clamps on the crankcase end of the housing. The beading at this end of the housing is directly on the end. The installation of the hose connections will be facilitated if a thin coat of engine oil is placed on the housing.

When assembling a push rod assembly, which was withdrawn without removing the rocker arm, proceed as follows: Oil the push rod ball ends and insert the push rod in its housing being sure the hose connection at the crankcase end is flush with the beading on the housing. Compress the valve spring using the tool described in the removal instructions. With the valve spring compressed, place the ball end of the push rod in the rocker arm ball socket and push the crankcase end of the push rod through the slot in the tappet guide and into the tappet ball socket. Slide the push rod housing hose connection into position at the rocker box. Push the push rod housing all the way into its rocker box hose connection and tighten the hose clamp. Slide the crankcase end hose connections over the tappet guide and tighten both hose clamps. Remove the valve spring compressing tool from the rocker arm. Set the valve tappet clearance in accordance with instructions given in the section entitled "Cylinders and Pistons".

If the rocker arm was removed when the push rod was removed, the following additional instructions are applicable. With the hose connections and clamps assembled on the push rod housing, install the housing on the rocker box connection and push the housing upward into the hose connection while tightening the clamp. Slide the crankcase end hose connections over the tappet guide and tighten both clamps. Oil the push rod ball ends with clean engine lubricating oil and insert in the push rod housing through the rocker box. Install a rocker arm and insert the rocker bolt through its hub. Ensure that the spherical seat washers are installed at each end of the through bolt, and that the push rod is seating properly in the ball sockets. The bolt should be installed with the head facing the cylinder center line.

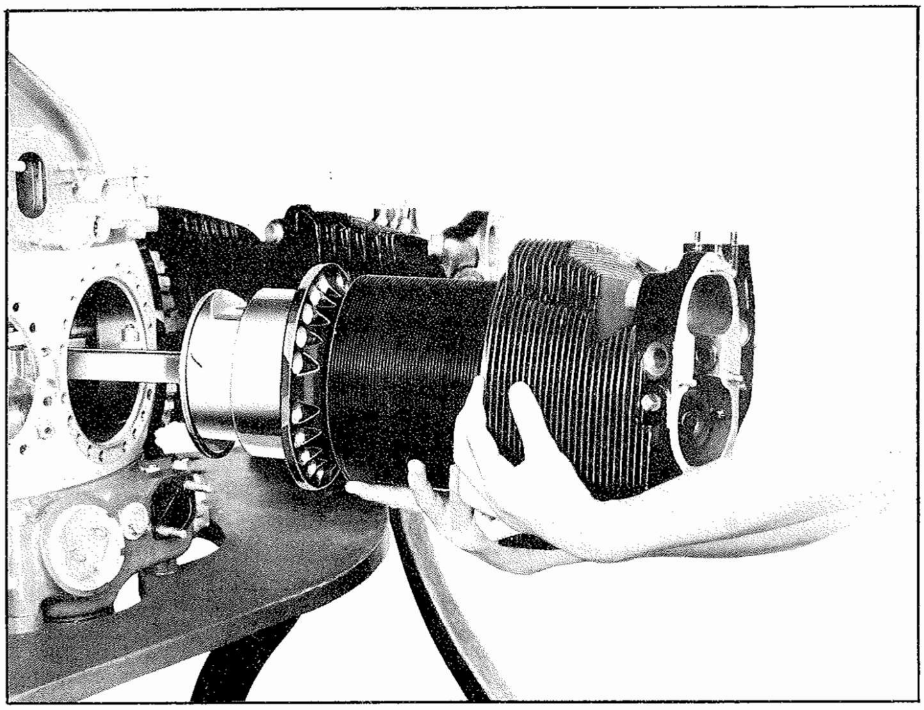
Before tightening a castellated nut on the rocker box, be sure the parts are installed exactly as they were removed.

Tighten the rocker bolt nut to the torque value specified in the Table of Limits using the torque wrench. If the hole in the bolt cannot be lined up when using the correct torque value, remove the nut and install a new washer. Repeat the above procedure. Check for the proper rocker arm bearing end play. Install a new cotter pin of the correct size in the rocker arm bolt nut.

Set the valve tappet clearance in accordance with the instructions given in the section titled "Cylinders and Pistons."

Lubricate the rocker boxes above the horizontal center line of the engine in the following manner: Fill the exhaust rocker boxes and push rod housings with clean engine oil of the same kind as is used in the engine. Partially fill the intake rocker boxes with clean engine oil of the same kind as is used in the engine. Install a new gasket and replace the rocker box covers, and tighten the nuts and washers. To lubricate the rocker boxes below the horizontal center line of the engine, first install a new gasket and secure the rocker box cover with nuts and washers. Before adjusting and tightening the push rod housing hose and clamps at the crankcase end of the push rod housing, fill the exhaust rocker box and push rod housing with oil by pouring into the end of the push rod housing. Partially fill the intake rocker box with oil by pouring into the end of the push rod housing. Replace the push rod housings and hoses in position and tighten the hose clamps.

Reinstall the ignition harness retaining clips on the push rod housing, if removed.



Removing Cylinder

CYLINDERS AND PISTONS Remove the four exhaust stack attaching nuts and lock washers. It may be found necessary to remove all or part of the exhaust manifold in order to facilitate the removal of the cylinder. Disconnect the ignition leads to the front and rear spark plug and remove the air deflectors and intake pipes in accordance with the instructions already given. Remove the rocker box covers, rocker arms, push rods, and housings.

To remove cylinders adjacent to the two main front to rear ignition shielding conduits, it will be necessary to remove all the attaching clamps, and loosen all the knurled nuts on the shield assembly. Otherwise the cylinder hold-down cap screws will not be accessible. To remove the cylinders adjacent to the oil sump, the sump must first be removed following the instructions as described in the section on the oil sump.

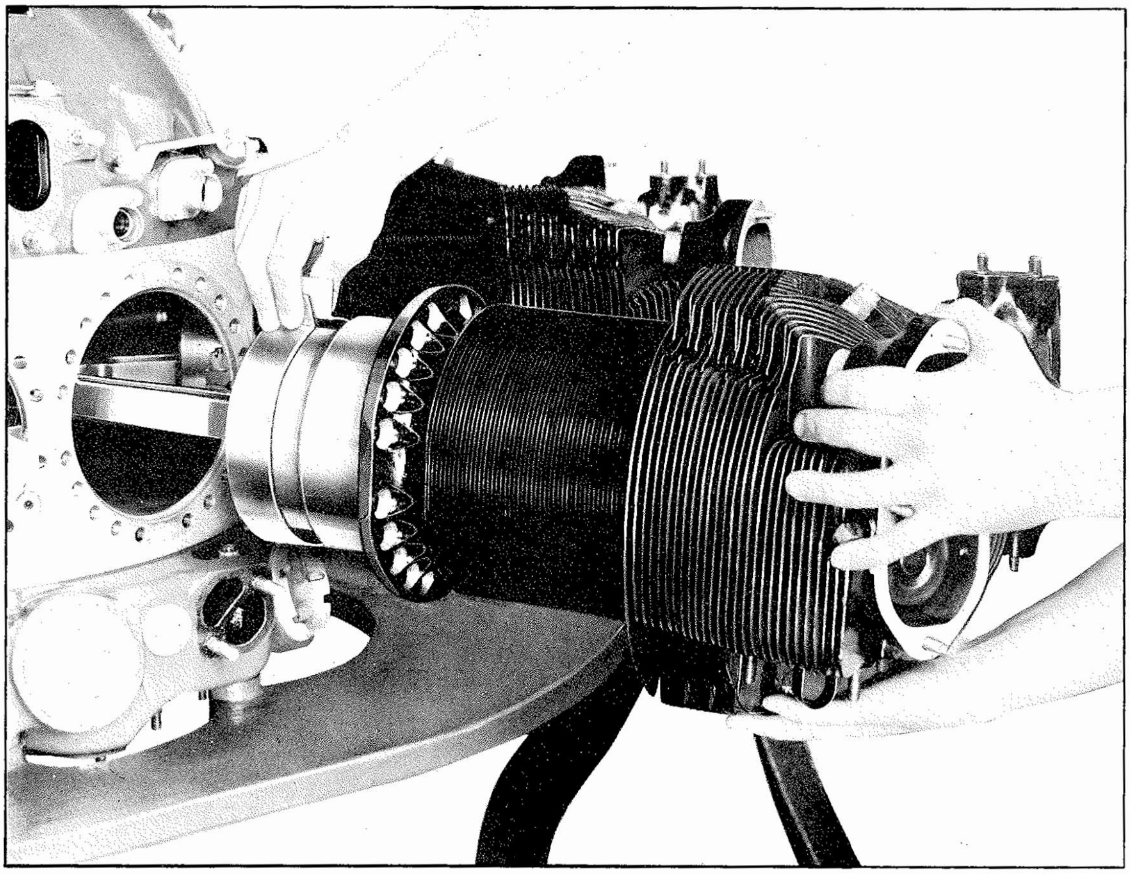
Remove the spark plugs. Turn the crankshaft until the piston of the cylinder being removed is at the top of its stroke. Break the lock wire from the cylinder hold-down cap screws and remove the cap screws. Remove the sperical seat washers from the cylinder flange, and pull the cylinder out straight clear of the piston.

As the cylinder is being removed from the engine, but before the cylinder skirt clears the bottom piston ring, a cloth or other cover should be drawn around the connecting rod and spread over the cylinder hole to prevent pieces of foreign material from falling into the crankcase.

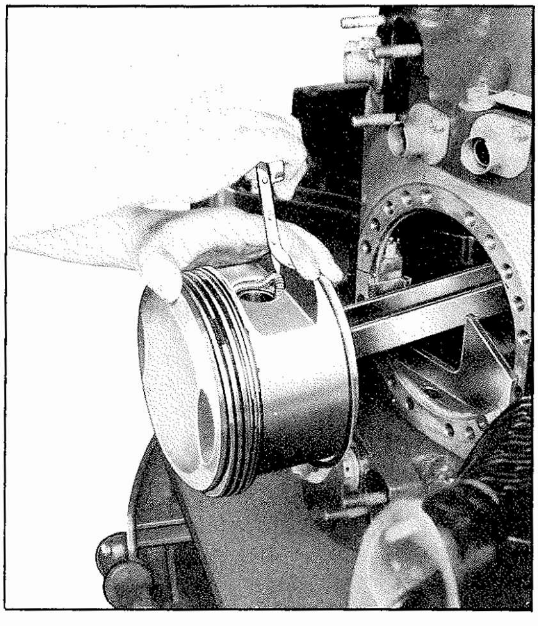
Install a connecting rod guide on the cylinder pad, and secure temporarily with two cap screws. Install a fin protector around the cylinder if the cylinder is to be used again.

To remove the piston, remove both piston pin retainers using the tool designed for this purpose. Insert the spade shaped end of the tool between two of the coils in the spring and turn the handle 90°. Pry out the spring, resting the leg of the tool against the wall of the piston Place one hand over the piston pin bore * catch the retainer as it is pried out. Push the piston pin out of the piston with the fingers.

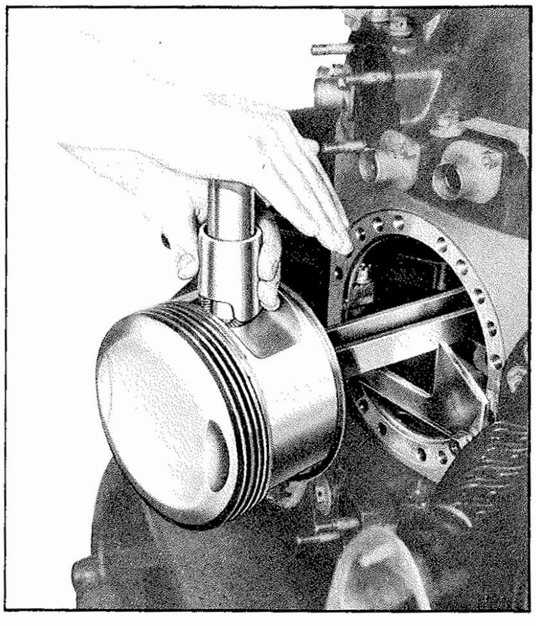
When installing a piston, insert a new piston pin retainer in the rear piston pin retainer groove of each piston. Place the retainer in the installing tool with the spring joint approximately 90° on either side of the cut-out in the tool. Install the piston pin in the piston with the large circumference of the chamfer flush with the inner edge of the retainer groove. Insert the end of the installing tool in the piston pin from the side of the piston in which the retainer is to be installed with a cut out portion of the tool at the



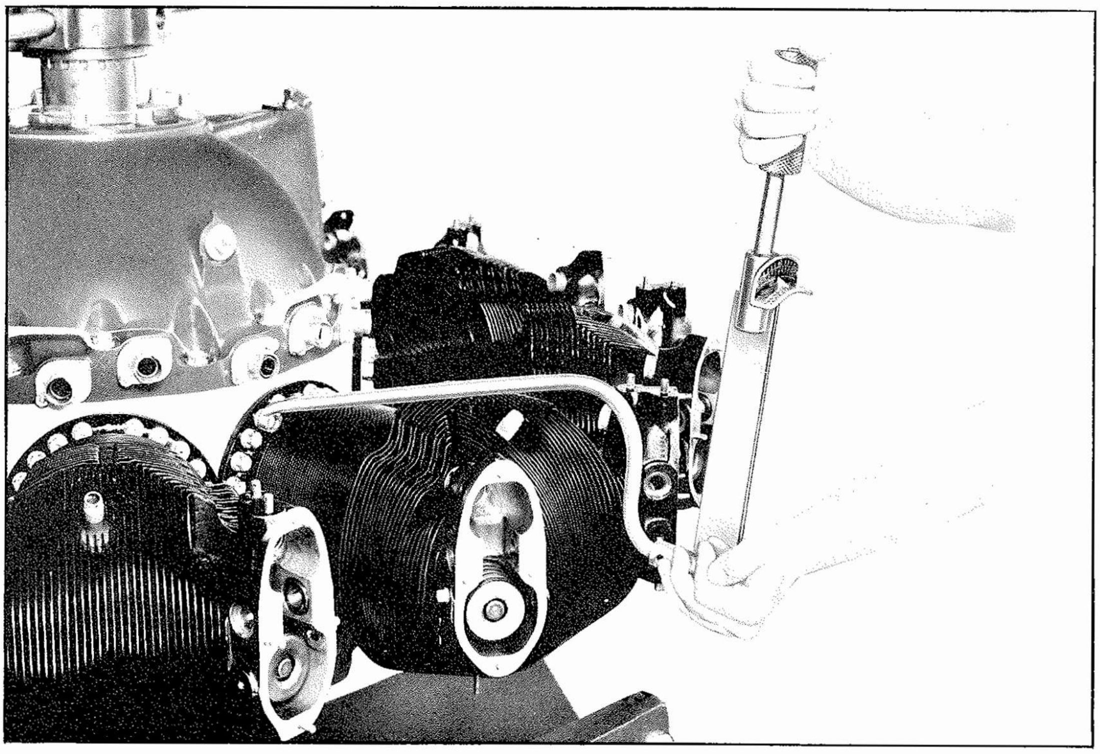
Installing Cylinder



Removing Piston Pin Retainer



Installing Piston Pin Retainer



Tightening Cylinder Hold-Down Cap Screw Using Torque Wrench

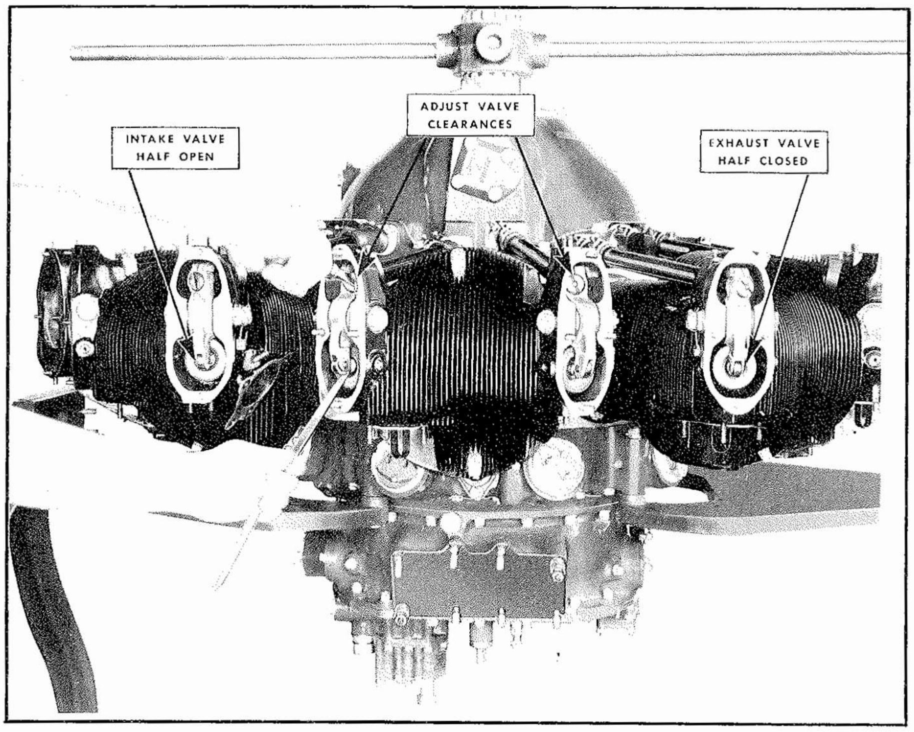
top of the piston pin hole. While performing this operation, locate the top section of the retainer spring in the top section of the groove. Install the adapter in the opposite end of the piston pin and while holding the tool in position with one hand, apply pressure on the installing tool with the other and force the spring into its seat in the retainer groove. Remove the installing tool and piston pin.

Turn the crankshaft so that the connecting rod is at the top of its stroke, oil the piston pin, connecting rod, piston pin, bushing, and piston pin bore with clean engine lubricating oil. Install the piston so that the part numbers stamped on the dome of the piston face the rear. Insert the piston pin so that the bottom is against the retainer spring previously installed. Install the remaining retainer in the same manner as the first using the installing tool. When installing the cylinder, coat the cylinder barrel bore with clean engine oil and install a new oil seal ring below the hold-down flange. Thoroughly coat the piston and rings with clean engine oil. However, do not use excessive oil because drainage into the combustion chamber may cause fouling of the spark plugs. Set the piston rings so that the gaps are equally staggered around the piston. Remove the connecting rod guide and protecting cover from the cylinder pad. Make sure that the cylinder pad is clean and dry.

Compress the upper piston rings with the flexible piston ring clamp and slide the cylinder over the piston. As soon as the top five rings have entered the cylinder, remove the clamp and inspect the piston pin retainers to ensure that they are in their proper positions. Install the clamp over the remaining ring compress the ring, and slide the cylinder into its proper location on the crankcase.

Install the two cylinder hold-down locating cap screws on opposite sides of the cylinder, and tighten with a torque wrench to approximately 300 in. lb. This prevents incorrect seating of spherical washers. Lubricate the regular hold-down cap screws with Glyptal and install finger tight with spherical seat washers under the heads. Do not install clamps, brackets, or other washers except those supplied with the engine under the cylinder hold-down cap screws.

Using a torque of approximately 300 in. lb. tighten two cap screws on opposite sides of the cylinder and approximately 90° from each of the locating cap screws. Using the same torque, tighten two more cap screws on opposite sides of the cylinder and approximately 45° from the



Setting Valve Tappet Clearance

last. Proceed in this manner until all cap screws are tightened. Remove the locating cap screws and replace with the standard cap screws and washers using approximately 300 in. lb. torque. Finally, tighten all of the cap screws consecutively around the cylinder, using the torque specified in the Table of Limits. (The following precautions will be observed when using a torque wrench: Make sure the wrench does not bind on any part of the engine. Install the wrench in such a position that the cap screw may be pushed up to the required tightness without interruption. The torque load should be applied until the bolt has ceased to turn. This requires several seconds from the time that the indicator reaches the desired torque value.)

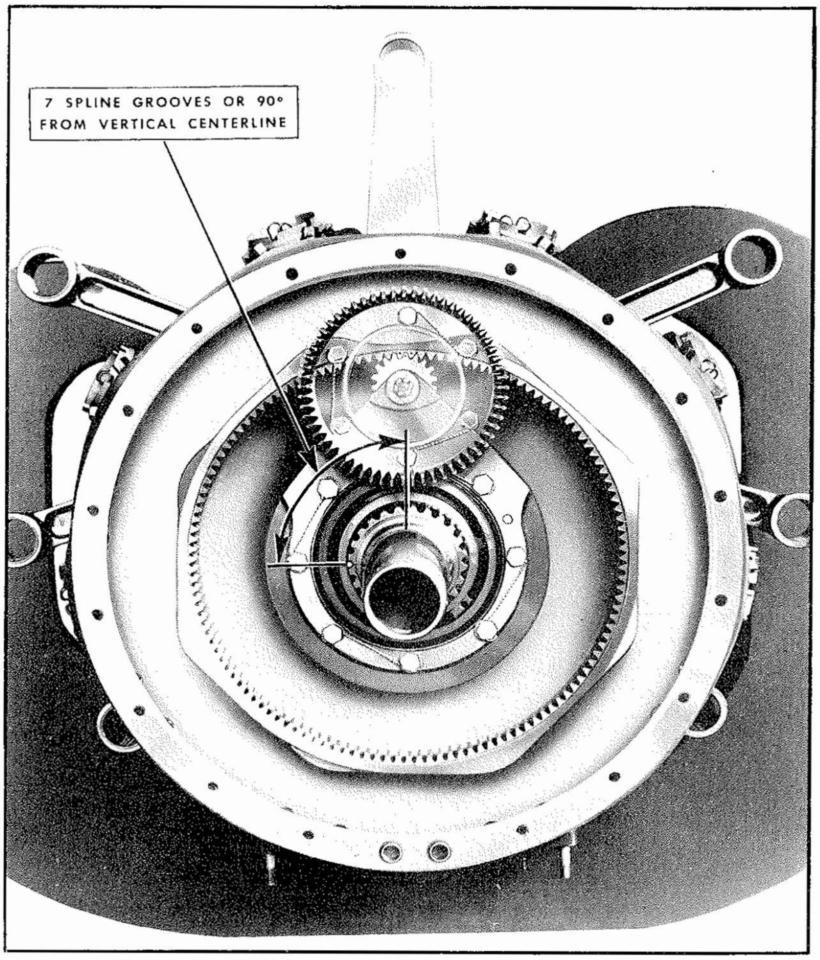
Install the spark plugs loosely in the cylinder head to prevent the entrance of foreign material.

Lockwire the cylinder hold-down cap screws using a length of wire for each group of five cap screws. Twist the wire one turn between cap screws and twist together securely at the ends.

Install the cylinder barrel air deflectors, oil sump, intake pipes, push rod housings, push rods, and rocker arms following the instructions given for each item.

Set the valve tappet clearance in accordance with the following instructions: Install the top dead center indicator in the front spark plug bushing of the cylinder in which the valve tappet clearance is being adjusted. Turn the crankshaft until the piston, in the cylinder on which the adjustment is being made, is at the top dead center position on the firing stroke (both valves closed) as shown on the indicator. Loosen the adjusting screw lock screw. Screw in the adjusting screw until the rocker arm roller bears against the valve stem and the tappet spring is fully compressed. Turn the adjusting screw in a counter-clockwise direction until .025 inch clearance is obtained as indicated by a strip of feeler stock. Tighten the adjusting screw lock screw, and check the adjusting screw for tightness. Recheck the clearance.

NOTE: The adjusting srew is drilled with three oil passages for lubrication of the rocker arm bearing. The position of these passages is indicated by three indexing marks on the top of the adjusting screw. Do not leave the adjusting screw in such a position that any of the indexing marks line up with the split in the push rod end of the rocker arm. If such a position is encountered, turn the adjusting screw in the shortest possible direction to correct this condition.



Correct Meshing of Cam Driving Gear Teeth

Adjust any remaining valve tappet clearances in accordance with the foregoing instructions.

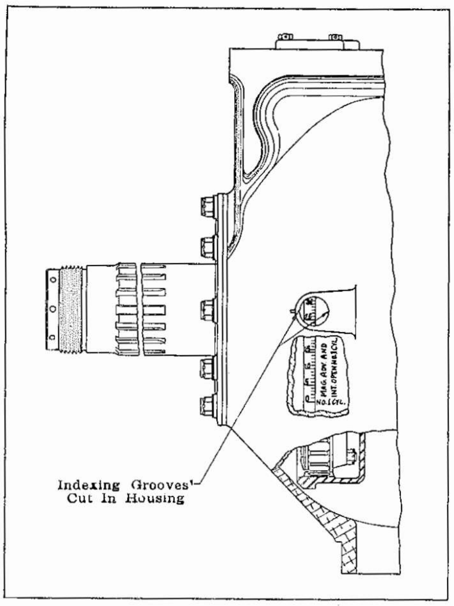
After installation of the cylinder above the horizontal center line, fill the rocker box with engine oil, as heretofore described, to assure ample lubrication when the engine is started for the first time. Install the rocker box covers with gaskets using a plain washer, a shake proof washer, and a nut on each of the attaching studs. Install the ignition wire attaching clamps on the proper push rod housings.

Tighten the spark plugs in the cylinder head, making sure copper gaskets or thermocouples are present under the shell of each plug. If the cylinders were installed adjacent to the two main radio shielded ignition conduits, it will be necessary to attach the retaining yokes and tighten the couplings of the radio shielding. Install the cylinder head air deflectors and connect the ignition terminals to the spark plugs. Install the exhaust stacks which were removed and reassemble the portion of the exhaust manifold which was removed or swung out of the way for cylinder removal. Tighten all bolts.

CRANK PIN OIL METERING JET If it is necessary to remove the crank pin oil metering jet when the engine is assembled and in the horizontal position, one of the lower cylinders, other than the master rod cylinder, should be removed. The removal of one of the lower cylinders will reduce the possibility of dropping jets or washers into the crankcase.

Remove and install the oil metering jet with the proper tool.

CHECKING VALVE TIMING Attach the timing disc to the starter mounting pad on the rear cover. Insert the top dead center indicator in number 1 cylinder, front



Timing Marks on Reduction Driving Gear

spark plug hole and check the accuracy of the pointer setting. To do this turn the crankshaft in the normal direction of rotation until the pointer on the top dead center indicator registers zero. Note the reading on the timing disc as indicated by the timing disc pointer. Continue to turn the crankshaft in the same direction until the pointer on the top dead center indicator has gone past and returned to the zero mark. Again note the reading on the timing disc. Turn the crankshaft backward about one quarter of a revolution; then turn it forward until the timing disc pointer indicates a point on the timing disc exactly midway between the two readings previously obtained. Allow the crankshaft to remain in this position and, if necessary, adjust the timing disc pointer so that it indicates zero degrees or top dead center on the timing disc.

Turn the crankshaft until number 1 piston is at top dead center on the firing stroke and adjust the valve clearance of both number 1 valves to .075 inch (1,90 ^{mm}). Again turn the crankshaft, in the normal direction of rotation, slightly less than one complete revolution or until number 1 piston is approximately 25° or 30° before top center. From this point tap the shaft forward slowly until number 1 intake rocker roller just contacts the valve tip indicating that the valve is starting to open. As soon as the roller tightens against the valve tip, note the reading on the timing disc. Continue to tap the shaft forward until No. 1 exhaust rocker roller is free, indicating that the exhaust valve has closed and note the reading of this point on the timing disc. If the cam gears have been meshed properly, the valve clearance adjusted accurately and the check carefully made, the readings obtained should check within a few degrees of the valve timing specification given on the engine data plate.

Upon completion of the check, reset the clearance of the valves to .025 inch (0,635 ^{mm}). Install the rocker box covers, and attach the intercylinder baffles to the extended lugs using the bolts and plates provided.

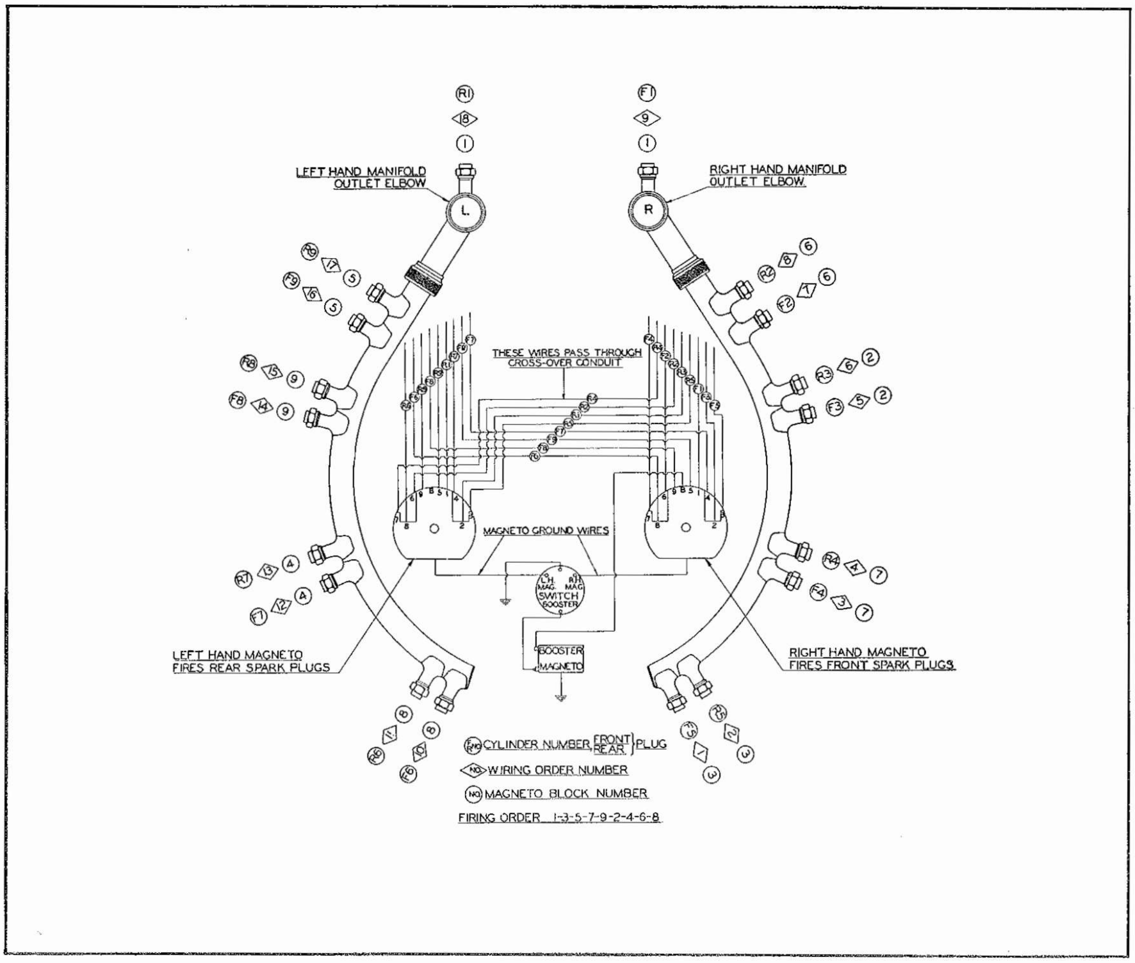
It is possible to check the valve timing by using the timing scale on the reduction driving gear instead of the timing disc, but only the position of the intake valve opening may be checked. To use this method, set the number 1 piston on top dead center on the firing stroke. Set the intake valve clearance at .075 inch (1,905 ^{mm}). Turn the crankshaft in the direction of normal rotation slightly less than one complete revolution, or until number 1 piston is approximately 25° to 30° before top center. From this point tap the shaft forward slowly until number 1 intake rocker roller just contacts the valve tip, indicating that the valve is starting to open. As soon as the roller tightens against the valve tip, note the reading on the reduction driving gear timing scale. This reading should check within a few degrees of the valve timing specification given on the engine data plate.

The point of exhaust valve closing will not fall within the limits of the timing scale on the gear and cannot be checked by this method.

PROPELLER SHAFT THRUST BEARING NUT To replace or check the tightness of the propeller shaft thrust bearing nut, it is necessary to remove the propeller in accordance with the applicable Propeller Handbook of Instructions. Slide the bronze rear centering cone forward off the propeller shaft.

The thrust bearing nut is slotted to accommodate a lug wrench in all propeller installations, except those in which a brush holder supplants the crankcase front section spacer for use with electrically controlled propellers. In the latter case, use an offset lug wrench which is constructed to clear the front face of the brush older.

Install a new thrust bearing nut and ring assembly observing the following instructions: Install the rings in their grooves and lubricate



Ignition Wiring Diagram

with engine oil. Lubricate the thrust nut threads and the oil seal rings, and screw the nut, complete with rings, on the propeller shaft. Compress the rings with a strip of brass to avoid damaging them upon entering the crankcase front section steel flange. Tighten the thrust bearing nut with the wrench provided, striking the handle with a lead hammer.

EXTERNAL OIL SCAVENGE LINE Remove the clamps and hoses from the oil pump and oil sump strainer ends of the external scavenge line tube. Remove the clamps and hose from the center where the front and rear tubes are joined. Remove the clamps and clips which support the tubes to the engine. If necessary, remove the oil sump strainer to which the external oil scavenge tube adapter is attached. Remove the adapter.

Install the external oil scavenge tubes by first inserting the adapter on the oil sump strainer and adjusting the adapter in the direction necessary to meet the tube. Lockwire the adapter nut and oil sump magnetic plug together. Using hoses and clamps, attach the tubes together, to the strainer adapter, and to oil pump inlet, being sure that the clamps and clips are on the tubes. Clamp the front tube to the push rod housing and the rear tube to the parting flange of the supercharger rear section. Ensure that all connections are tight.

GENERATOR Disconnect all wires attached to the generator. Remove the six palnuts, nuts, and washers. Lift off the generator.

When installing the generator, remove the gasket and wipe the mounting pad clean. Replace the gasket and mount the generator on the mounting pad. Secure firmly with nuts, washers, and palnuts. Connect all wires. The wire terminals are marked for identification and

should be connected to the corresponding generator terminals. Do not draw the leads too tightly or tape them together as the resulting stiffness will minimize the effectiveness of the shock mountings.

STARTER Disconnect all lead and ground wires, and dismount starter by removing six palnuts, nuts, and washers.

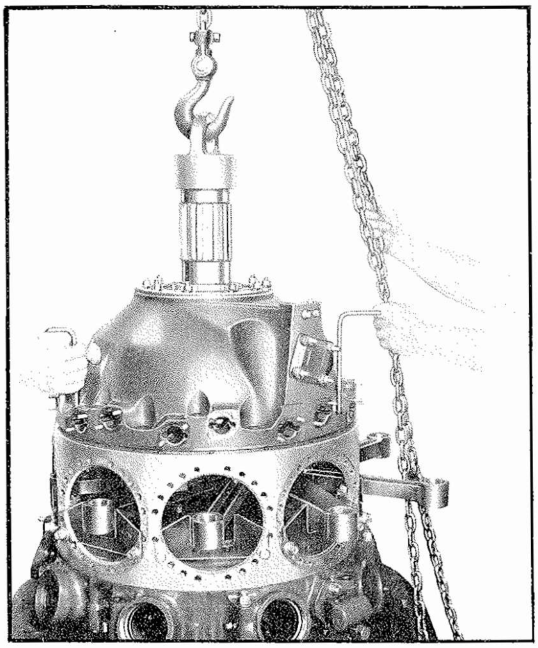
When installing the starter, examine the starter and crankshaft to ascertain whether the engine dog and starter dog are the same. Remove the gasket and wipe the mounting pad clean. Replace the gasket and mount the starter on the starter mounting pad. Secure firmly with washers, nuts, and palnuts. Connect lead and ground wires.

PROPELLER GOVERNOR The four studs which secure the propeller governor to the crankcase front section are a hand fit in the bushings, and no wrench or stud driver should be used to tighten these studs.

Break the lock wire and remove the four nuts and washers. Remove the governor.

Check the governor for freedom of movement, and, if any binding is observed, this should be investigated and corrected before installation.

Mount the governor on the engine mounting pad. The pilot on the governor should enter the opening on the mounting pad freely. The governor stud nuts should then be drawn down finger tight, the governor head removed, and the pump gear checked for freedom of movement as the nuts are tightened. The nuts should be drawn down equally to the proper torque value. The propeller should then be rotated to at least three positions and the governor checked for freedom of movement at each point. Replace the governor head. Secure the governor stud nuts with lock wire.



Removing Crankcase Front Section

BREATHER TUBE Remove the lock wire and the three screws which secure the propeller shaft breather screen to the breather tube nut. Remove the screen. Using the proper wrench, remove the breather tube nut. Remove the hydro oil connection and gasket, and withdraw the breather tube and rear gasket.

To install the crankshaft breather, insert the rear support gasket, breather tube, and front gasket. Install the hydro oil connection, the lock nut, and screen over this assembly and secure the screen with three lock screws. Secure the screws with lock wire.

CRANKCASE FRONT SECTION To install a new crankcase front assembly with the same reduction gear or to install a crankcase front section with a torque indicator, it will first be necessary to remove the propeller, propeller thrust nut, the air deflectors between cylinders number 1 and 2, and 1 and 9, and the ignition harness. It may be sufficient to disconnect the ignition harness at its joints and move it to one side. The valve tappets and guides must also be removed before pulling the front section, because they will not pass the reduction driving gear which is fastened to the crankshaft. Therefore, the rocker box covers, push rod housings, and push rods must also be removed. Disconnect external oil scavenge lines, if used, from the sump and remove the sump.

Remove the lock wire and cap screws holding the front section to the crankcase main section. Remove the puller hole plugs in the front section mounting flange and insert the pullers. Long screws with the same thread as the pullers may be used if the pullers are not available. Turn the pullers evenly and lift off the front section.

Front sections of engines equipped with 3:2 ratio reduction gears are installed so that there is a direct relationship between the crankshaft position and the propeller position. To install a

3:2 ratio front section, proceed as follows: Place a top dead center indicator in No. 1 cylinder and set the piston on top dead center. Place the pointer and turning tool on the propeller shaft so that the wide spline space in the tool encloses splines numbers 1 and 16. Turn the propeller shaft until the pointer indexes with the center of the timing mark on the front section flange. Raise the front section assembly. Install a new rubber seal ring in the front section oil channel, and a new packing ring around the locating shoulder on the crankcase main section. Slush the cam lobes and the exposed portion of the crankshaft with clean engine oil, and lower the front section into position, engaging the pinions with the reduction driving gear. If engagement is not possible with the propeller shaft in this position, turn the propeller shaft to obtain tooth meshing in the nearest tooth location. The pointer must still fall within the limits of the timing mark when this adjustment is made. When the gears have been properly meshed, check the top dead center indicator position to make certain that the crankshaft has not been turned.

Apply a few drops of Glyptal to the attaching cap screws and install them after placing the ignition manifold brackets in the proper position. Tighten the cap screws to the proper torque value and lockwire. Install the tappet guides and tappets, using new gaskets, and secure with nuts and palnuts.

Front sections of engines equipped with 16:9 ratio reduction gears are assembled to the engine in the manner just described except that it is not necessary to maintain any definite relationship between the positions of the crankshaft and propeller shaft.

FUEL PUMP DRIVE SHAFT AND OIL SEAL REPLACEMENT After removing the fuel pump and gasket from the engine, use pullers or long bolts to pull out the fuel pump drive shaft support, shaft, and oil seal as a unit. Remove the gasket.

Replace the unit by first installing the gasket. Tap in the fuel pump drive shaft support with the shaft and oil seal included, using a fibre drift if necessary. Replace the fuel pump or cover if the pump is not to be installed at this time.

Connect the fuel lines and the fuel pump drain tube.

GENERATOR AND MAGNETO DRIVE SHAFT OIL SEALS To remove the generator or magneto drive shaft oil seals, proceed as follows: Remove the six fillister head screws and shake-proof washers which secure the oil seal retainer to the rear cover. Tighten two screws having a number 10-32 thread in two tapped holes in the retainer to remove the retainer. Remove the retainer. Remove the oil seal collar using the appropriate puller. Remove the oilite seal, diaphragm, flanged thrust washer, and spring. Discard the diaphragm.

To replace the generator or magneto drive shaft oil seals, proceed as follows:

Assemble a new neoprene diaphragm on the hub of the flanged oil seal thrust washer and install the oilite retaining ring over the diaphragm. Place the oil seal spring over the drive gear in the recess of the supercharger rear housing cover. Install the oil seal assembly over the end of the drive gear. Take care to insure that the lobes on the outside circumference of the thrust washer are lined up with the grooves in the rear cover, and that the holes in the diaphragm are lined up with the oil seal attaching screw holes. Place the oil seal collar on the splines of the installing tool. Engage the splines on the tool with the internal splines in the gear shaft and drive the collar into position on the gear. Install the retainer over the oil seal assembly and secure the six attaching cap screws and shake proof lock washers.

STARTER OIL SEAL RING Remove the twelve flat head screws in the starter oil seal retaining ring. Remove the ring and the gasket. Remove the starter oil seal packing from the flange of the starter coupling.

Replace the oil seal ring and insert it against the starter coupling flange. Secure the oil seal in place by reinstalling the gasket, retaining ring, and twelve screws.

HYDROMATIC PROPELLER In order to change from an electric propeller to a hydraulically controlled propeller it will be necessary to replace several parts in the propeller shaft with parts used with a hydraulically operated propeller.

Break the lock wire and remove the three cap screws, screen, nut, and the cover. If a plug is used in place of the cover, remove the plug.

Install the special adapter and install the propeller, following the manufacturer's instructions.

CORROSION PREVENTIVE, COMPOUND
(Aircraft Engine)

1. **ACKNOWLEDGMENT:** A vendor must mention this specification number in all quotations and when acknowledging purchase orders.

2. **TYPE:** (a) This specification is for a compound consisting of a mixture of aircraft engine lubricating oil and a corrosion inhibitive agent as an additive.

   (b) When specified by the purchaser the corrosion inhibitive agent and lubricating oil may be purchased independently.

3. **USE:** This compound shall be suitable for the preservation of metal parts of aircraft engines during shipment and storage, and for lubricating the engine while operating as specified.

4. **QUALITY:** The compound shall form a continuous, completely protective film on metals by any method of application, and shall be readily removed by spraying with kerosene or by the use of wiping cloths saturated with kerosene .

5. **REQUIREMENTS:**

(a) Viscosity Seconds, at 210° F. (Saybolt Universal) 100-125
Viscosity Index (Dean & Davis (min)..........................95*
Pour Point °F. (max) 20
Volatile Matter per cent (by weight) (max) 5
Flash Point °F. (min) 350
Carbon Residue per cent (max) 2.5
Ash per cent (max) 1.5
Precipitation Number per cent (max) 0.1

(*NOTE: This requirement applicable unless otherwise specified by purchaser.)

(b) Solubility: The compound shall be completely soluble in all percentages at 70° to 80° F. and in all grades of aircraft engine lubricating oil of 95 minimum viscosity index. An artificially aged sample of the compound shall show no separation within 24 hours when mixed with an equal volume of aircraft engine lubricating oil, as detailed in section 6 (c).

(c) Humidity: A film of the mixture shall protect low carbon steel panels for a minimum of 150 hours in a humidity cabinet with an atmosphere maintained at 120° F. ± 5° F. and 95-100% R.H., as detailed in section 6 (d).

(d) Hydrobromic Acid Neutralization: The compound shall retard hydrobromic acid corrosion. This characteristic shall be determined as detailed in section 6(e).

(e) Effect on the Color Indicating Properties of Cobalt Chloride Impregnated Silica Gel: The mixture shall show no adverse effect on the property of the cobalt chloride impregnation of silica gel to indicate the relative humidity at any time, as detailed in section 6 (f).

(f) Corrosiveness: The compound shall not be corrosive to any metal nor have an adverse effect on any other substance used in the engine.

(g) Lubrication: The compound shall be capable of satisfactorily lubricating an aircraft engine for at least 30 minutes, operating at 50% power.

6. **TESTS:** (a) Methods: Unless otherwise specified, all tests shall be conducted in accordance with ASTM methods.

   (b) Viscosity shall be determined after all volatile matter has been removed.

   (c) Solubility: A quantity of compound sufficient to allow the recovery of 50 ml. after aging shall be placed in a flat bottomed container so that the film thickness does not exceed 3 mm. This dish shall be placed in an

oven at 200° F. for 24 hours. Following aging, 50 ml. of the compound shall be mixed thoroughly with 50 ml. of aircraft engine lubricating oil in a 100 ml. stoppered glass graduate. There shall be no separation after 24 hours.

(d) Humidity: Two 2" x 4" sand blasted panels of low carbon steel shall be dipped in the compound so as to completely submerge all surfaces and shall then be suspended vertically in an atmosphere maintained at 77° F. ± 5° and 50-55% R.H. for four hours. At the end of this period the panels shall be suspended vertically in a humidity cabinet maintained at 120° F. ± 5° and 95-100% R.H. for one hundred and fifty hours under conditions of dynamic atmosphere. The air in the cabinet shall circulate at such a rate as to cause approximately one complete air change each twelve minutes. The panels shall then be removed from the cabinet, cleaned with naphtha and examined. Visible corrosion of either surface, except within 1/8" from any edge, shall be cause for rejection of the material.

(e) Hydrobromic Acid Neutralization: Two 2" x 4" sand blasted panels of low carbon steel shall be dipped in a 10% emulsion of 0.2% hydrobromic acid solution in aircraft engine lubricating oil and slushed vigorously for one minute. The panels shall then be immediately immersed in the corrosion preventive compound and allowed to remain thirty seconds completely submerged. The panels shall then be hung vertically in a humidity cabinet maintained at 120° F. ± 5° and 95-100% R.H. At the end of the period the panels shall be cleaned with naphtha and examined for corrosion. Pitting, corrosion or other attack involving either surface, except within 1/8" from any edge, shall be cause for rejection of the corrosion preventive compound.

(f) Effect of the Compound on Color Indicating Properties of Cobalt Chloride Impregnated Silica Gel: Two activated dehydrator plugs, AS 7, shall be used for this test. One plug shall be immersed in the compound maintained at 100° F. until the contained silica gel is fully saturated with the mixture. The other plug shall be immersed in aircraft engine lubricating oil also maintained at 100° F. and similarly saturated. Both plugs shall then be removed and placed in a vertical position permitting the excess oil to drain out of the perforated end. After one hour of drainage, both plugs shall be placed in an upright position, perforated ends up, and distilled water at room temperature shall be dropped into the gel in both plugs, one drop at a time, permitting the water to percolate into the gel. After filling, the plugs shall be undisturbed for 30 minutes. At the end of this period the gel in the two plugs shall be compared with respect to color. Differences in color, not attributable to reproductibility of this test for plugs tested with lubricating oil, shall be cause for rejection of the corrosion preventive compound.

(g) Volatile Matter: Ten, plus or minus one (10 ± 1), grams of the compound shall be weighed into a red dish approximately 10 cm. in diameter and 3 cm. in depth. The dish shall be heated on a steam bath for four hours, and the loss of weight determined.

7. **REPORTS:** The manufacturer shall supply three copies of a notarized report of the quantitative results of tests made on the batch of the corrosion preventive compound from which the order was filled. This report shall also include the purchase order number, material specification number, batch number, quantity, and date of shipment.

8. **IDENTIFICATION:** All containers shall be plainly marked to show this specification number, the purchase order number, quantity, batch number, and the manufacturer's name or trade mark.

9. **APPROVAL:** A manufacturer shall not begin to supply a product to this specification until samples have been approved by the purchaser and after approval the ingredients and method of manufacture shall not be changed without his permission. Results of tests on incoming shipments shall be as good as or better than those on approved samples.

10. **REJECTION:** Material not conforming to this specification or modifications specified on the purchase order is subject to rejection. If samples for verification are desired by the vendor, they must be claimed within three weeks. Rejected material will be held a reasonable time, at the vendor's risk, awaiting shipping instructions for the return of same for credit or replacement, as specified. The vendor shall pay all transportation charges.

NOTE: **SIMILAR SPECIFICATIONS:**. Army-Navy Aeronautical AN-VV-C-576 is listed here for information only and shall not be construed as an acceptable alternate unless all requirements for this AMS are met.

AERONAUTICAL MATERIAL SPECIFICATION
AMS 3070

CORROSION PREVENTIVE – OIL
(Carburetor Slushing)

1. **ACKNOWLEDGEMENT:** A vendor must mention this specification number in all quotations and when acknowledging purchase orders.
2. **USE:** The material shall be suitable for protecting the interior of carburetors from corrosion during shipment and storage.
3. **QUALITY:** The material shall be refined petroleum oil without the admixture of fatty oils, fatty acids, resins, soaps, or other non-hydrocarbon materials.
4. **REQUIREMENTS:**

Viscosity: Saybolt Universal Seconds at 130° F.	120-145
Viscosity index (min)	105
Flash Point °F. (min)	415
Pour Point °F. (max)	0
Carbon Residue per cent (max)	0.6
Neutralization Number (max)	0.1
Sulphur per cent (max)	0.5
Corrosion Test at 212° F. (copper strip)	no discoloration or pitting
Cloud Point °F. (max)	20
Precipitation	0
Analine Point ° (min)	200

5. **TESTS:** (a) All tests to determine conformance to the requirements of this specification shall be made in accordance with A.S.T.M. methods, except the corrosion test, which shall be made as directed in paragraph 5 (b) below.

   (b) Corrosion. Place a clean strip of mechanically polished pure copper ½" wide by 3" long in a clean test tube and cover completely with the sample to be tested. Close the tube with a vented stopper and maintain at 212° F. for 3 hours. Rinse the copper strip with sulphur free acetone and compare with a similar strip of freshly polished copper. Corrosion, indicated by discoloration or pitting, must be absent.

6. **REPORTS:** Unless otherwise specified, the vendor shall supply three copies of a certified report of the quantitative results of tests made on the batch of material from which the order was filled. This report shall include the purchase order number, material specification number, quantity and date of shipment.
7. **IDENTIFICATION:** All containers shall be plainly marked with this specification number, purchase order number, and quantity.
8. **APPROVAL:** A manufacturer shall not begin to supply a product to this specification until samples have been approved by the purchaser, and after approval the ingredients, and method of manufacture shall not be changed without his permission. Results of tests on incoming shipments shall be as good as, or better than those on the approved samples.
9. **REJECTIONS:** Material not conforming to this specification or modifications specified on the purchase order is subject to rejection. If samples for verification are desired by the vendor, they must be claimed within three weeks. Rejected material will be held a reasonable time at the vendor's risk awaiting shipping instructions for the return of same for credit or replacement as specified. The vendor shall pay all transportation charges.

NOTE: **SIMILAR SPECIFICATIONS:** Army-Navy Aeronautical AN-VV-O-446 Grade 1065A is listed for information only and shall not be construed as an acceptable alternate unless all requirements of this AMS are met.

WRIGHT AERONAUTICAL MATERIAL SPECIFICATION
No. 5817C

LUBRICATING OIL

1. This specification supersedes all previous issues or letters of instruction.

2. This specification covers one viscosity classification of engine lubricating oil known as Grade 120. The use of other viscosities is permitted only by special consent of the Wright Aeronautical Corporation and such permission should be secured by application.

3. All oils shall be approved by Wright Aeronautical Corporation only after a full scale engine test has been made in accordance with Wright Aeronautical Corporation standard practice for engine testing of lubricating oil. After approval of an oil, results of laboratory tests on shipments shall be identical with the approved sample within the accuracy prescribed by A.S.T.M. for the test in question.

4. The oil shall be free from water, and any other injurious materials.

5. The oil supplied under this specification shall be tested by the latest revised A.S.T.M. Methods, as applicable, and shall conform to the following requirements, unless otherwise specified:

Viscosity at 210° F. (98.9° C)	115-125
Pour Point	+ 20° F. (-6° C) max
Flash Point	490° F. (254° C) min
Fire Point	590° F. (310° C) min
Carbon Residue	1.00 max
Ash	none
Neutralization Number	0.10 max
Precipitation	none
Evaporation Loss	0.50 max
Sulphur (Bomb Method)	0.50 max

The oil shall separate completely (no cuff) in one hour from an emulsion with distilled water at 180° F. (82.2° C).

The viscosity at 100° F. (37.7° C) shall not be more than 14.5 times the viscosity at 210° F. (98.9° C) and the viscosity index shall be not less than 95.

A clean strip of freshly polished copper shall show no indications of corrosion when submerged in the oil for three hours at 212° F. (100° C).

6. The vendor shall furnish three copies of a certified report giving the results of all tests specified. This report shall also include the specification number, order number, and quantity. This report shall be delivered before or at the same time as the oil. The oil is not considered received until this report is received.

7. Material not conforming to this specification, or modifications specified on the purchase order, is subject to rejection. If samples for verification are desired by the vendor, they must be claimed within three weeks. Rejected material will be held a reasonable time, at vendor's risk, awaiting shipping instructions for the return of same for credit or replacement, as specified. Vendor shall pay all transportation charges.

WRIGHT AERONAUTICAL MATERIAL SPECIFICATION
No. 5806 C

AVIATION GASOLINE
91 OCTANE

1. This specification supersedes all previous issues or letters of instruction.

2. Gasoline covered by this specification shall be of one grade only; known as Aviation Grade, 91 Octane Number.

3. Gasoline consisting of a blend of refined hydrocarbons derived from crude petroleum, natural gasoline, or blends thereof with synthetic hydrocarbons and/or aromatic hydrocarbons will be considered. Each component of the gasoline must be of such quality as to assure satisfactory performance in the concentration in which it is present in the blend.

4. Benzol and similar aromatic hydrocarbons may be added in such quantity that the blend meets all requirements for the finished fuel.

5. The gasoline covered by this specification shall not contain more than 4.00 cc lead tetraethyl per U. S. gallon in the form of 1-T Ethyl Fluid.

6. The gasoline shall be free from water and suspended matter.

7. The anti-knock value shall be equal to that of a mixture of 91 parts iso-octane and 9 parts normal heptane, the proportions being by volume.

8. The anti-knock value shall be determined by direct comparison between a sample of the fuel and specific primary standard octane heptane-mixture, or a secondary standard proved equal to the primary standard in anti-knock value under the specified conditions of test.

9. The anti-knock value shall be determined by test in a C.F.R. engine by the C.F.R. Method of test for knock characteristics of aviation fuels, 1940.

10. The following active inhibitors may be added separately or in combination to the fuel in total concentration not to exceed 1.0 pound of inhibitor (not including weight of solvent) per 5000 gallons of fuel in order to prevent the formation of gum and the precipitation of lead compounds:

    Monobenzyl-para-aminophenol
    Isobutyl-para-aminophenol
    Normal butyl-para-aminophenol
    N, N' dibutyl-para-phenylenediamine
    Ortho, Meta, and Para-Cresols
    Alpha-Naphthol

11. The color of the gasoline shall be not darker than 21 Saybolt before addition of any dye. If toxic detonation inhibitors have been added, the color shall be light blue.

No. 5806 C

12. The distillation range shall be as follows:

    Thermometer reading 158°F or 70°C—not less than 10% shall be evaporated
    Thermometer reading 212°F or 100°C—not less than 50% shall be evaporated
    Thermometer reading 257°F or 125°C—not less than 90% shall be evaporated
    The sum of the individual temperatures of 10% and 50% evaporated points shall not be less than 307°F or 135°C.
    The distillation residue shall not exceed 1.5%.
    The distillation loss shall not exceed 1.5%.

13. The residue after distillation shall not show an acid reaction.

14. Sulfur shall not be over 0.5% by weight.

15. One hundred milliliters of the gasoline shall cause no gray or black corrosion when evaporated in a polished copper dish and residue in dish shall not exceed 5 mg.

16. A clean mechanically polished copper strip after immersion in gasoline at 122°F or 50°C for three hours shall be free from gray or black corrosive discoloration.

17. The gum residue after the accelerated aging test shall not exceed six milligrams per one hundred milliliters.

18. The Reid vapor pressure at 100°F or 37.8°C shall not exceed seven pounds per square inch or 0.492 kilograms per square centimeter.

19. The gasoline shall separate promptly from water as determined by the water tolerance test.

20. The freezing point shall not be higher than minus 76°F or minus 60°C.

21. The net calorific or lower heat value of the fuel shall not be less than 18,700 B.T.U. per pound.

22. The latest revision of A.S.T.M. Test Methods shall be employed wherever applicable.

23. The vendor shall furnish three copies of a certified report giving the results of all tests specified. This report shall also include the unit amount of tetraethyl lead or other detonation inhibitors, specific gravity, specification number, order number, car numbers and quantity. This report shall be delivered before or at the same time as the gasoline. The anti-knock value shall be reported to the exact octane number secured in the engine test and not a specified value within the tolerance of the test method. The gasoline is not considered received until the report is received.

24. Unless otherwise specified, all material will be inspected at destination and material failing to comply with this specification will be rejected and held a reasonable time for disposition by the manufacturer who shall pay all transportation charges.

WRIGHT AERONAUTICAL MATERIAL SPECIFICATION
No. 5804 C

AVIATION GASOLINE
100 OCTANE

1. This specification supersedes all previous issues or letters of instruction.

2. Gasoline covered by this specification shall be of one grade only; known as Aviation Grade, 100 Octane Number.

3. Gasoline consisting of a blend of refined hydrocarbons derived from crude petroleum, natural gasoline, or blends thereof with synthetic hydrocarbons and/or aromatic hydrocarbons will be considered. Each component of the gasoline must be of such quality as to assure satisfactory performance in the concentration in which it is present in the blend.

4. Benzol and similar aromatic hydrocarbons may be added in such quantity that the blend meets all requirements for the finished fuel.

5. The gasoline covered by this specification shall not contain more than 4.00 cc lead tetraethyl per U. S. gallon in the form of 1-T Ethyl Fluid.

6. The gasoline shall be free from water and suspended matter.

7. The anti-knock value shall be equal to that of iso-octane.

8. The anti-knock value shall be determined by direct comparison between a sample of the fuel and specific primary standard octane heptane-mixture, or a secondary standard proved equal to the primary standard in anti-knock value under the specified conditions of test.

9. The anti-knock value shall be determined by test in a C.F.R. engine by the C.F.R. Method of test for knock characteristics of aviation fuels, 1940.

10. The following active inhibitors may be added separately or in combination to the fuel in total concentration not to exceed 1.0 pound of inhibitor (not including weight of solvent) per 5000 gallons of fuel in order to prevent the formation of gum and the precipitation of lead compounds:

    Monobenzyl-para-aminophenol
    Isobutyl-para-aminophenol
    Normal butyl-para-aminophenol
    N, N' dibutyl-para-phenylenediamine
    Ortho, Meta, and Para-Cresols
    Alpha-Naphthol

11. The color of the gasoline shall be not darker than 21 Saybolt before addition of any dye. If toxic detonation inhibitors have been added, the color shall be light blue.

No. 5804 C

12. The distillation range shall be as follows:

    Thermometer reading 158°F or 70°C—not less than 10% shall be evaporated
    Thermometer reading 212°F or 100°C—not less than 50% shall be evaporated
    Thermometer reading 257°F or 125°C—not less than 90% shall be evaporated
    The sum of the individual temperatures of 10% and 50% evaporated points shall not be less than 307°F or 135°C.
    The distillation residue shall not exceed 1.5%.
    The distillation loss shall not exceed 1.5%.

13. The residue after distillation shall not show an acid reaction.

14. Sulfur shall not be over 0.5% by weight.

15. One hundred milliliters of the gasoline shall cause no gray or black corrosion when evaporated in a polished copper dish and residue in dish shall not exceed 5 mg.

16. A clean mechanically polished copper strip after immersion in gasoline at 122°F or 50°C for three hours shall be free from gray or black corrosive discoloration.

17. The gum residue after the accelerated aging test shall not exceed six milligrams per one hundred milliliters.

18. The Reid vapor pressure at 100°F or 37.8°C shall not exceed seven pounds per square inch or 0.492 kilograms per square centimeter.

19. The gasoline shall separate promptly from water as determined by the water tolerance test.

20. The freezing point shall not be higher than minus 76°F or minus 60°C.

21. The net calorific or lower heat value of the fuel shall not be less than 18,700 B.T.U. per pound.

22. The latest revision of A.S.T.M. Test Methods shall be employed wherever applicable.

23. The vendor shall furnish three copies of a certified report giving the results of all tests specified. This report shall also include the unit amount of tetraethyl lead or other detonation inhibitors, specific gravity, specification number, order number, car numbers and quantity. This report shall be delivered before or at the same time as the gasoline. The anti-knock value shall be reported to the exact octane number secured in the engine test and not a specified value within the tolerance of the test method. The gasoline is not considered received until the report is received.

24. Unless otherwise specified, all material will be inspected at destination and material failing to comply with this specification will be rejected and held a reasonable time for disposition by the manufacturer who shall pay all transportation charges.

WRIGHT CYCLONE 9-GC

TABLE OF LIMITS TL—45 —— TIGHTENING TORQUE VALUES

ALL MODELS

All changes in the Table of Limits are issued as Service Bulletins by the Service Division, Wright Aeronautical Corporation.

Standard Studs, Bolts, Screws, and Cap Screws

Name	Size of Thread Nut End	Min. Dia. of Thread Root or Neck (Inches)	Min. Rockwell Hardness	Torque Values							
				Driving Stud				Tightening Nut, Screw or Cap Screw			
				Minimum		Maximum		Minimum		Maximum	
				In. Lbs.	Cm Kg	In. Lbs.	Cm Kg	In. Lbs.	Cm Kg	In. Lbs.	Cm Kg
Button Head Screw	10-32	0.1467	B-50	——	——	——	——	20	23,1	25	28,8
Button Head Screw	12-24	0.1585	B-50	——	——	——	——	25	28,8	30	34,6
Studs, Bolts, Screws and Cap Screws	10-32	0.1467	C-19	——	——	——	——	35	40,4	40	46,1
"	12-24	0.1585	C-19	——	——	——	——	45	51,9	50	57,6
"	1/4-28	0.180	C-26	50	57,6	70	80,7	80	92,3	85	98,0
"	5/16-24	0.229	C-26	100	115,2	150	173,0	160	184,5	175	202,0
"	3/8-24	0.285	C-26	200	231,0	275	317,0	225	259,5	250	288,0
"	7/16-20	0.331	C-26	300	346,0	425	490,0	350	404,0	375	432,0
"	1/2-20	0.387	C-26	500	576,0	700	807,0	550	635,0	600	692,0
"	9/16-18	0.436	C-26	750	865,0	975	1123,0	825	950,0	875	1008,0
"	5/8-18	0.493	C-26	1100	1269,0	1400	1614,0	1125	1297,0	1200	1383,0
Standard Practices for Special Applications											
Cyl. Hold-Down Stud	3/8-24	0.313	C-32	325	375,0	450	519,0	350	404,0	375	432,0
Cyl. Hold-Down Cap Screw	7/16-20	0.330	C-26	——	——	——	——	375	432,0	400	461,0
Cyl. Hold-Down Stud	7/16-20	0.331	C-32	400	461,0	550	635,0	425	490,0	450	519,0
Rocker Hub Bolt	7/16-20	0.371	C-32	——	——	——	——	250	288,0	325	375,0
Rocker Hub Bolt	15/32-20	0.400	C-19	——	——	——	——	250	288,0	325	375,0
Rocker Hub Bolt	9/16-18	0.488	C-26	——	——	——	——	300	346,0	375	432,0
Spark Plug	18 mm	——	——	——	——	——	——	450	519,0	500	576,0

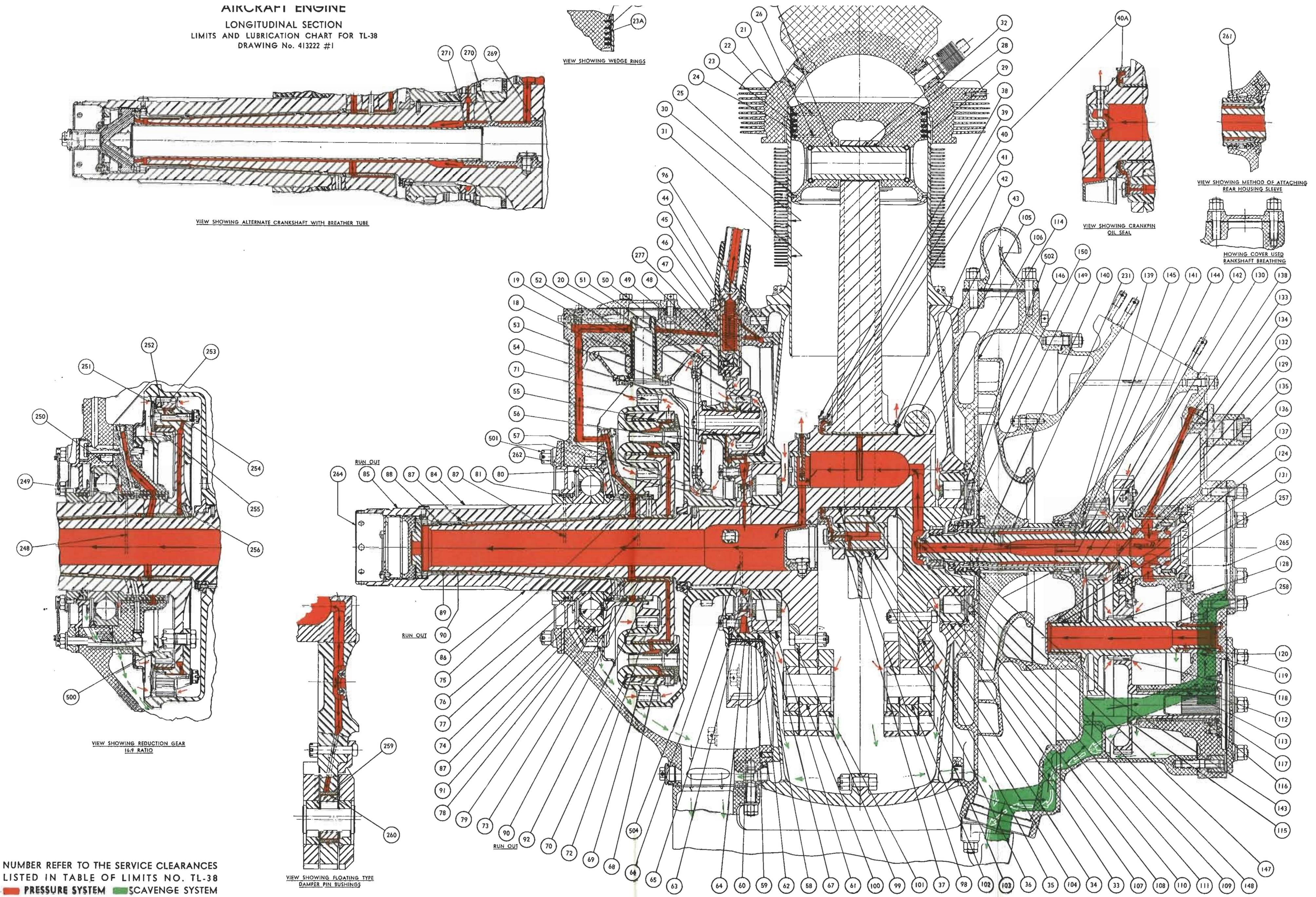
Excerpts of Torque Values for C9-GC Engines from Table of Limits TL—38

Crankcase front cover attaching nut and screw 300—350 inch pounds. (Threads must be lubricated with oil.)

Valve clearance adjusting screw lockscrew (with tapered head). 135—150 inch pounds.

AIRCRAFT ENGINE

LONGITUDINAL SECTION
LIMITS AND LUBRICATION CHART FOR TL-38
DRAWING No. 413222 #1



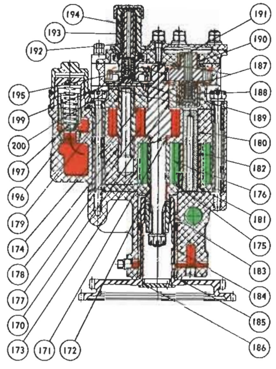
NUMBER REFER TO THE SERVICE CLEARANCES
LISTED IN TABLE OF LIMITS NO. TL-38
PRESSURE SYSTEM SCAVENGE SYSTEM

SEPTEMBER, 1942

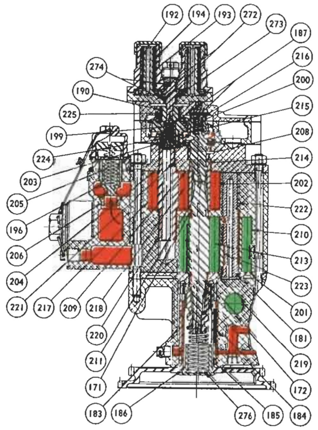
WRIGHT CYCLONE 9 GC AIRCRAFT ENGINE

SECTION THROUGH ACCESSORY DRIVES

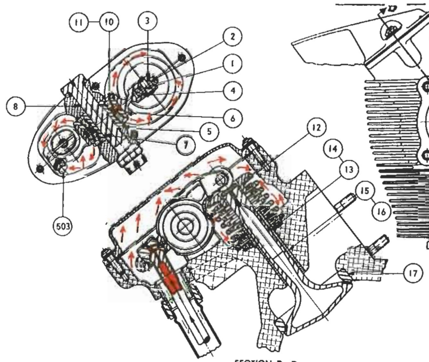
LIMITS AND LUBRICATION CHART FOR TL-38
DRAWING No. 413222 #2



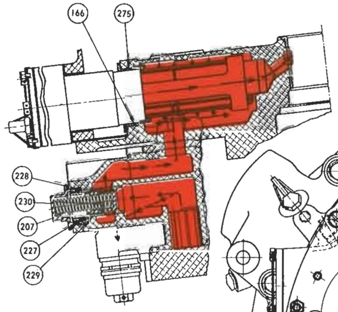
VIEW SHOWING ALTERNATE OIL PUMP



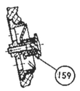
SECTION H-H



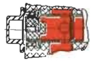
SECTION D-D



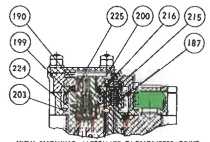
SECTION THRU CHECK VALVE AND OIL FILTER



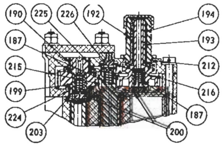
SECTION L-L



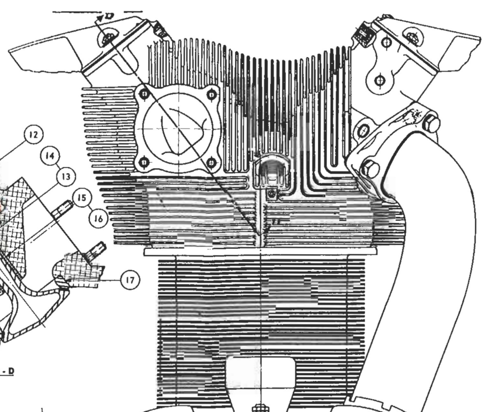
ALTERNATE SECTION SHOWING CHECK VALVE REMOVED AND PLUGGED

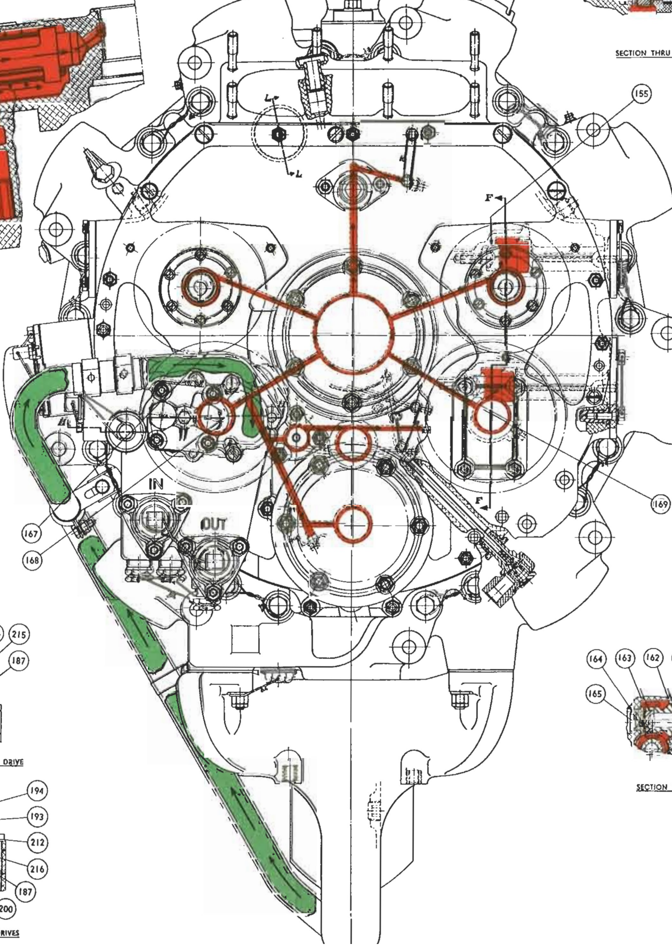


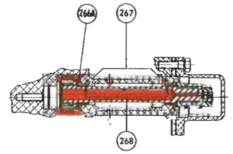
VIEW SHOWING ALTERNATE TACHOMETER DRIVE (Single Electrical)



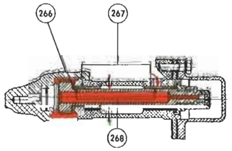
VIEW SHOWING ALTERNATE TACHOMETER DRIVES (Single Electrical and Single Mechanical)



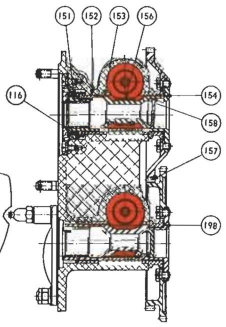




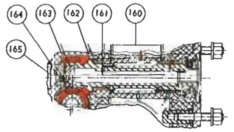
VIEW SHOWING ALTERNATE GUN SYNCHRONIZER DRIVE



SECTION THRU GUN SYNCHRONIZER DRIVE



SECTION F-F



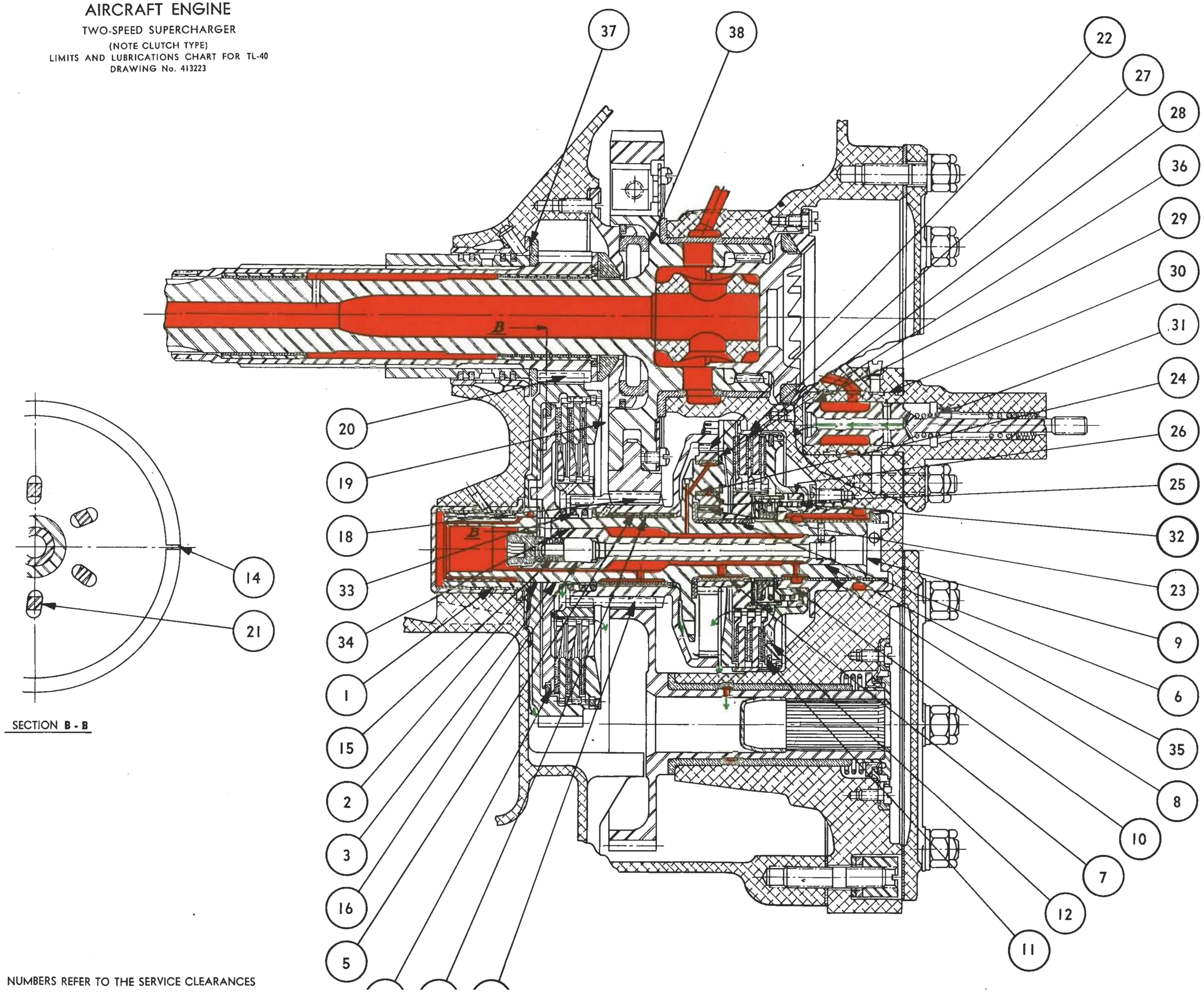
SECTION THRU FUEL PUMP DRIVE

NUMBER REFER TO THE SERVICE CLEARANCES

SEPTEMBER, 1942

WRIGHT CYCLONE 9 GC
AIRCRAFT ENGINE

TWO-SPEED SUPERCHARGER
(NOTE CLUTCH TYPE)
LIMITS AND LUBRICATIONS CHART FOR TL-40
DRAWING No. 413223



NUMBERS REFER TO THE SERVICE CLEARANCES

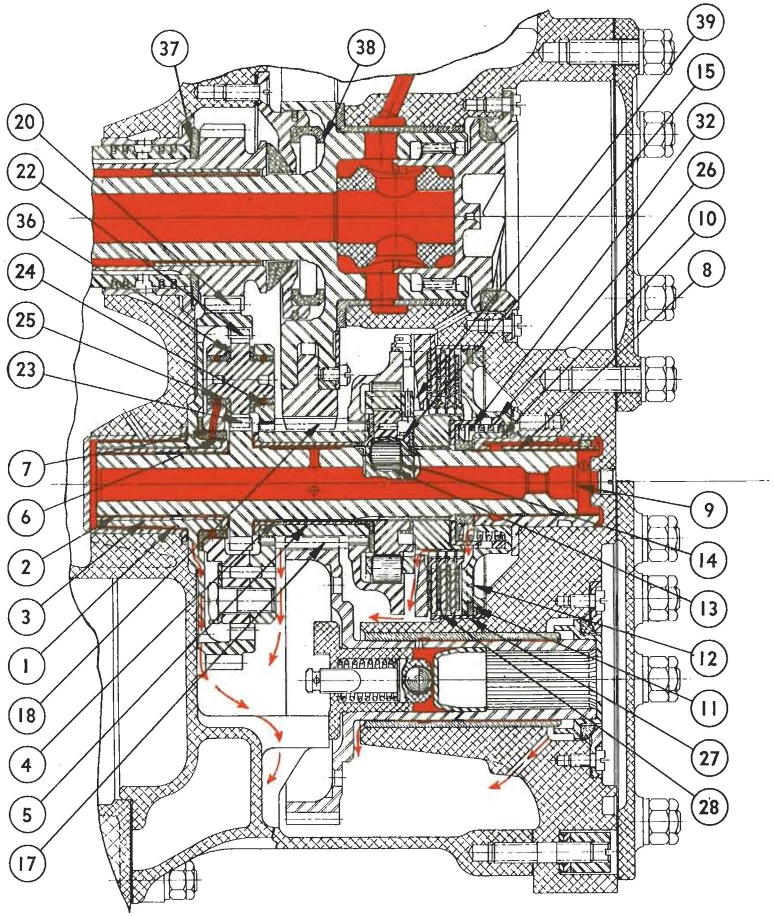
WRIGHT CYCLONE 9 GC AIRCRAFT ENGINE

TWO-SPEED SUPERCHARGER

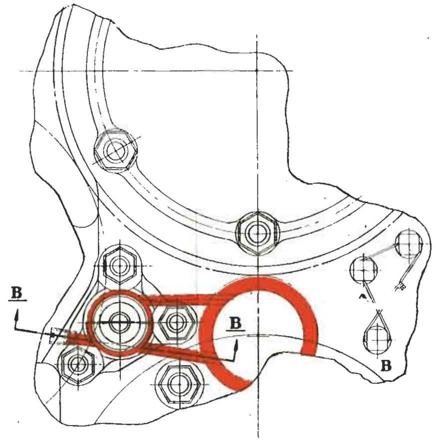
(ROLLER CLUTCH TYPE)

LIMITS AND LUBRICATION CHART FOR TL-87

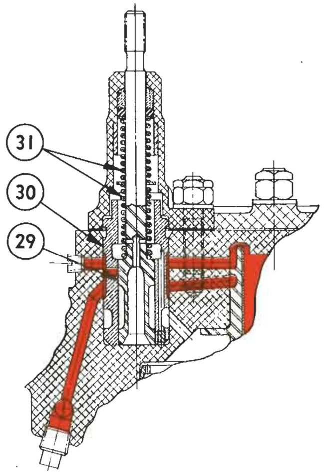
DRAWING No. 416189



RATIO 7.134:1 & 10.04:1



VIEW SHOWING
SUPERCHARGER CLUTCH OIL CONTROL VALVE



SECTION B - B

NUMBERS REFER TO THE SERVICE CLEARANCES
LISTED IN TABLE OF LIMITS NO. TL - 87

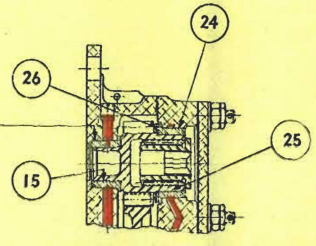
PRESSURE SYSTEM

WRIGHT CYCLONE 9 GC
AIRCRAFT ENGINE

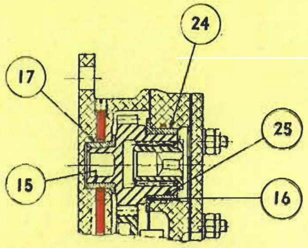
DUAL ACCESSORY DRIVES AND GUN SYNCHRONIZER

LIMITS AND LUBRICATION CHART FOR TL-30

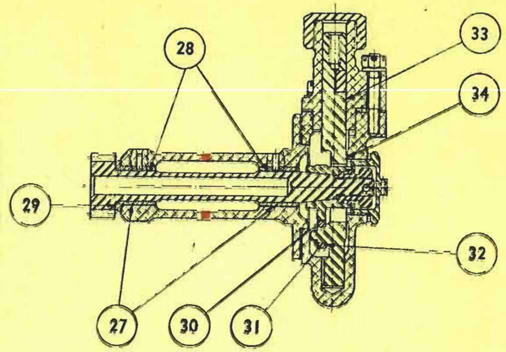
DRAWING No. 410150



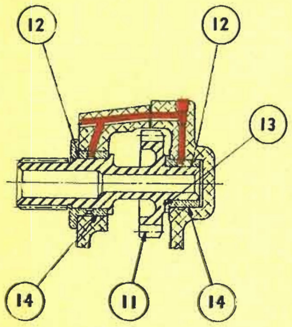
SECTION THRU UPPER VACUUM PUMP DRIVE COUPLING HAVING INVOLUTE SPLINE (SPECIAL)



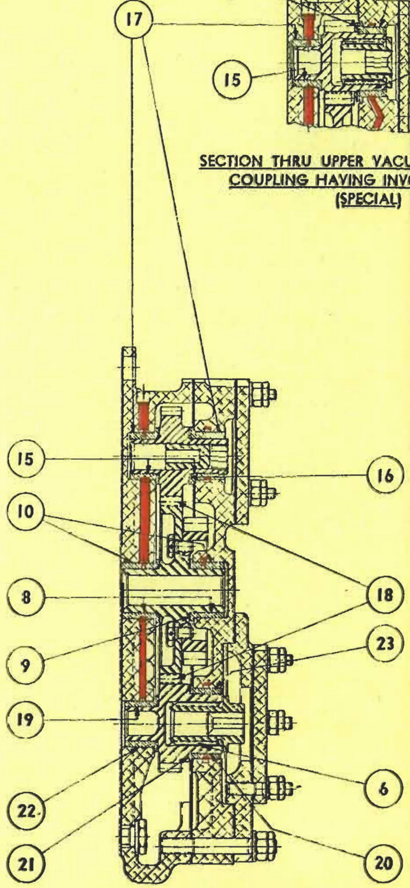
SECTION THRU UPPER VACUUM PUMP DRIVE COUPLING HAVING INVOLUTE SPLINE (STANDARD)



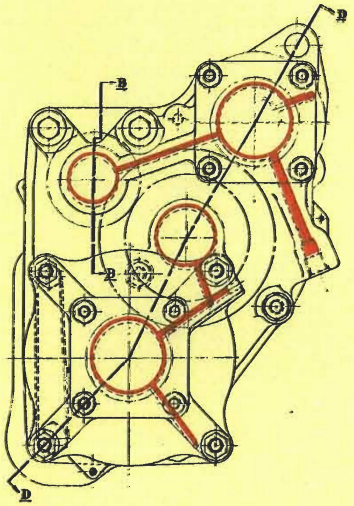
SECTION THRU GUN SYNCHRONIZER



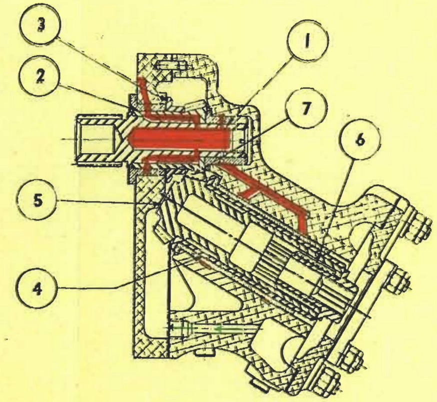
SECTION B - B



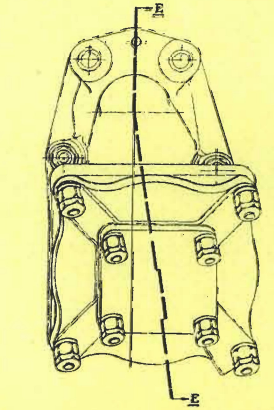
SECTION D - D



DUAL ACCESSORY DRIVE



SECTION E - E



ANGLE ACCESSORY DRIVE

NUMBER REFER TO THE SERVICE CLEARANCES LISTED IN TABLE OF LIMITS NO. TL-30

PRESSURE SYSTEM SCAVENGE SYSTEM

SEPTEMBER, 1942

WRIGHT CYCLONE 9 GC AIRCRAFT ENGINE

INSTALLATION DRAWING
DRAWING No. 412810